BUREAU OF WATER QUALITY
PROGRAM GUIDANCE

Wisconsin 2020 Consolidated Assessment and Listing Methodology (WisCALM) for CWA Section 303(d) and 305(b) Integrated Reporting

Guidance #
Date

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Cover photo: Brule River Flowage in Florence County, Photo by Luke Ernster.

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Background

Over 15,000 lakes and 84,000 miles of streams and rivers in Wisconsin are managed to ensure that their water quality condition meets state and federal standards. Water quality standards (WQS) are the foundation of Wisconsin's water quality management program and serve to define goals for a waterbody by designating its uses, setting criteria to protect those uses, and establishing provisions to protect water quality from pollutants.

Waters are monitored to collect water quality data to determine, or *assess*, its current status or condition. Water quality monitoring results and assessment data are stored in state and federal databases and the majority of data are available online to agencies and the public. *General assessments* are known as "305(b) assessments" in the Federal CWA (CWA). Waters with available data are reviewed by Wisconsin Department of Natural Resources (WDNR) biologists and placed in one three categories: attaining, not attaining, or insufficient information. If biological data is available the water will further be placed in one of four categories: excellent, good, fair and poor, as defined in section 3.1 of this document.

Specific assessments are conducted to determine if a waterbody is "impaired" or not meeting WQS. Waters that do not meet WQS are placed on Wisconsin's Impaired Waters List—also known as the 303(d) list—under Section 303(d) of the CWA. Wisconsin is required to submit list updates every 2 years to the United States Environmental Protection Agency (EPA) for approval. WDNR has submitted Impaired Waters Lists, as required[1], every other year since 1996.

Water quality assessments aid Department staff in determining management actions that are needed to meet WQS, including anti-degradation, or maintenance, of existing water quality condition, as well as restoration of impaired waters.

Each state must document the methodology used to assess waters, including how the state makes decisions to add or delete waters from the existing Impaired Waters List. Waters may be removed from the list (delisted) when water quality data identifies that the designated use has been restored (i.e., the water is meeting WQS). The methodology for conducting general and specific assessments is outlined, and updated for 2020, in this WisCALM guidance document.

[1] EPA did not require and WDNR did not submit an Impaired Waters List in FFY 2000.

1.0 Water Quality Standards: Three Elements

Wisconsin's assessment process begins with water quality standards (WQS). WDNR is authorized to establish WQS that are consistent with the CWA (Public Law 92-500) through Chapter 281 of the Wisconsin Statutes. These WQS are explained in detail in chs. NR 102, 103, 104, 105, and 207 of the Wisconsin Administrative Code (Wis. Adm. Code).

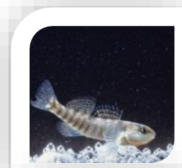
The WQS described in the Wis. Adm. Code rely on three elements to collectively meet the goal of protecting and enhancing the state's surface waters:

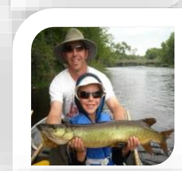
- *Use designations*, which define the goals for a waterbody by designating its uses,
- *Water quality criteria*, which are set to protect the water body's designated uses, and
- *Anti-degradation provisions* to protect water quality from declining.

Waters not meeting one or more of these water quality elements are to be included on the Impaired Waters List.

Designated Uses

Designated uses are goals or intended uses for surface waterbodies in Wisconsin which are classified into the categories of: Aquatic Life, Recreation, Public Health and Welfare, and Wildlife. The following designated uses are described in ch. NR 102, Wis. Adm. Code:





Aquatic Life[2]*:* All surface waters are considered appropriate for the protection of fish and other aquatic life. Surface waters vary naturally with respect to factors like temperature, flow, habitat, and water chemistry. This variation allows different types of fish and aquatic life communities to be supported.

Recreation*:* All surface waters are considered appropriate for Recreation use unless a sanitary survey has been completed to show that humans are unlikely to participate in activities requiring full body immersion.

Public Health and Welfare*:* All surface waters are considered appropriate to protect for incidental contact and ingestion by humans and human consumption of fish. All waters of the Great Lakes as well as a small number of inland water bodies are also identified as public water supplies and have associated water quality criteria to account for human consumption[3].

Wildlife*:* All surface waters are considered appropriate for the protection of wildlife that relies directly on the water to exist or rely on it to provide food for existence.

Use Designations for Aquatic Life (AL) are separated into the following sub-categories: Coldwater (Cold), Warmwater Sport Fish (WWSF), Warmwater Forage Fish (WWFF), Limited Forage Fish (LFF) and Limited Aquatic Life (LAL). More detail on these subcategories is in the Streams and River Classification chapter of this report.

[2] Aquatic Life use was formerly called 'Fish and Aquatic Life'. The word 'Fish' was removed because it was redundant.
[3] Distinct water quality criteria are specified for public water supply and non-public water supply waters.

Water Quality Criteria – Numeric and Narrative

Each designated use has its own set of water quality criteria, either numeric or narrative requirements that must be met to protect the intended use. Some of these requirements relate to the amount of the physical (e.g., water temperature) or chemical (e.g., ammonia concentrations) conditions that must be met to avoid causing harm. Wisconsin's water quality criteria may be either numeric (quantitative) or narrative (qualitative) and are authorized by state statutes and enumerated in chs. NR 102, 104, and 105, Wis. Adm. Code.

Numeric criteria: Numeric criteria are quantitative and are expressed as a particular concentration of a substance or an acceptable range for a substance. For example, the pH value shall be from 6-9 standard units. Numeric surface water quality criteria have been established for conventional parameters (e.g., dissolved oxygen, pH, and temperature), toxics (e.g., metals, organics, and ammonia), and pathogens (e.g., *E. coli* and fecal coliform bacteria). These numeric criteria are established for each designated use.

Narrative criteria: All waterbodies must meet a set of narrative criteria which qualitatively describe the conditions that should be achieved. A narrative water quality criterion is a statement that prohibits unacceptable conditions in or upon the water, such as floating solids, scum, or nuisance algae blooms that interfere with public rights. These standards protect surface waters and aquatic biota from eutrophication, algae blooms, and turbidity, among other things. The association between a narrative criterion and a waterbody's designated use is less well defined than it is for numeric criteria; however, most narrative standards protect aesthetic or Aquatic Life designated uses. Wisconsin's narrative criteria are found in s. NR 102.04(1), Wis. Adm. Code.

Anti-degradation

Wisconsin's anti-degradation policy is intended to maintain and protect existing uses and high-quality waters. This part of a waterbody quality standard is intended to prevent water quality from lowering, especially when reasonable control measures are available. The anti-degradation policy in Wisconsin is stated in s. NR 102.05(1) of the Wis. Adm. Code:

> "No waters of the state shall be lowered in quality unless it has been affirmatively demonstrated to WDNR that such a change is justified as a result of necessary economic and social development, provided that no new or increased effluent interferes with or becomes injurious to any assigned uses made of or presently possible in such waters."

One component of Wisconsin's anti-degradation policy is the designation of Outstanding Resource Waters (ORW) and Exceptional Resource Waters (ERW). These are surface waters which provide outstanding recreational opportunities, support valuable fisheries and wildlife habitat, have good water quality, and are not significantly impacted by human activities. ORWs typically do not have any dischargers, while ERW designation offers limited exceptions for dischargers if human health would otherwise be compromised (e.g., expansion of wastewater treatment facilities to protect public health).

Inherent in the assessment and impaired waters listing process is the application of anti-degradation provisions. Anti-degradation is an important aspect of pollution control because preventing deterioration of surface waters is less costly to society than attempting to restore waters once they have become degraded.

How is a water designated ORW or ERW?

ORWs are listed in NR 102.10 and include national and state wild and scenic rivers. ERWs are listed in NR102.11. Surface waters, or portions thereof, may be added to, or deleted from, the outstanding resource waters and exceptional resources waters designations through the rule making process. This process may be changed in the future.

2.0 Wisconsin's Monitoring Program and Data Management

2.1 Water Quality Monitoring

Wisconsin DNR's Water Division Monitoring Strategy is available on WDNR's website at: https://dnr.wi.gov/topic/SurfaceWater/monitoring/strategy/Strategy_2015_2020

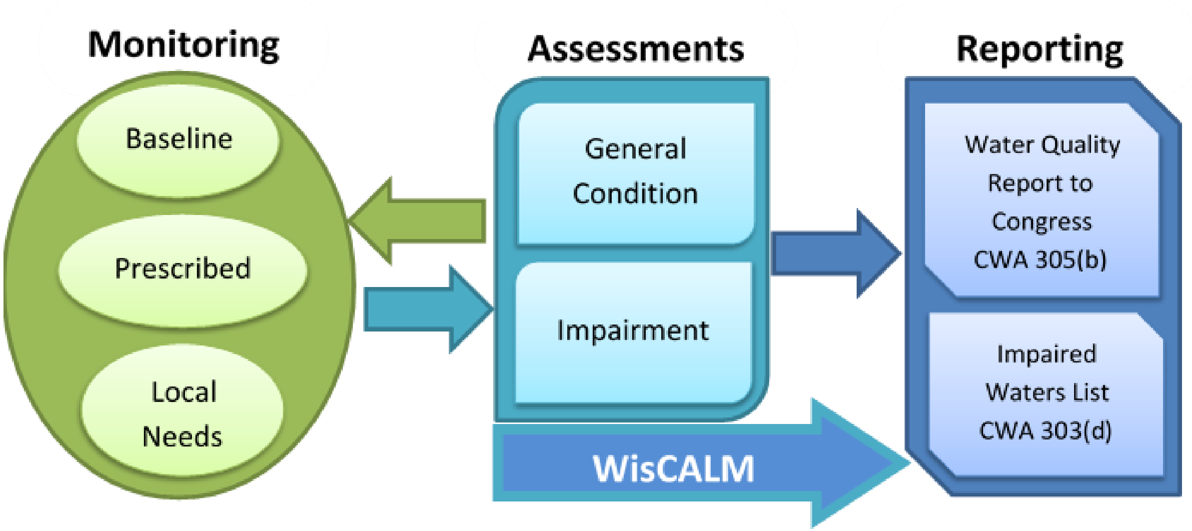
WDNR's Surface Water Monitoring Strategy directs monitoring efforts in a manner that efficiently addresses the wide variety of information needs, while providing adequate depth of surface water knowledge to support decision making. A stratified monitoring approach to gathering information ensures that the status of Wisconsin's water resources can be determined in a comprehensive manner, without depleting the capacity to conduct in-depth analyses and problem-solving where needed. Monitoring activities are grouped into three types, baseline, prescribed, and local needs, which form the basis of the integrated reporting process (
Figure 1).

Baseline Monitoring – Statewide
- Trends sites (Lakes, Rivers)
- Probabilistic surveys (streams, Aquatic Invasive Species (AIS), National Aquatic Resource Surveys (NARS) (coastal condition and wetlands))
- Reference sites (wadeable streams, macrophytes, large river macroinvertebrates)

Prescribed Monitoring – Statewide and District
- Targeted Watershed Approach
- Directed Lake Assessment (including Aquatic Plant Management (APM) and Critical Habitat)
- 319 (non-point) Project Evaluation
- Follow-up for Impaired Waters

Local Needs Monitoring – District Initiated
- Cross program support
- Unique stressors, projects

Figure 1. Wisconsin's integrated reporting process.



2.2 Use of Monitoring Data from Other Sources

In addition to Department-generated data, WDNR biennially seeks information from partners and the public to use in its assessment of waterbodies. Partners include: the U.S. Geological Survey, EPA, U.S. Fish and Wildlife Service, other state agencies, universities, regional planning commissions and major municipal sewerage districts. Guidance is provided on how to submit third party data on the WDNR assessment website [https://dnr.wi.gov/topic/SurfaceWater/assessments.html]. GovDelivery, a web-based service used by WDNR, is also used to solicit data from citizens. This service offers the public real-time updates on topics of interest via email or text messages and is also used to provide information regarding the Integrated Reporting Process and Wisconsin's Impaired Waters Program. Any one is able to sign up for GovDelivery emails for a number of topics on WDNR's website: https://public.govdelivery.com/accounts/WIDNR/subscriber/new.

As datasets are submitted, WDNR reviews the data and the procedures used to collect and analyze the data. WDNR will review information provided by any individual or group at any time; however, the data used for listing purposes must have been obtained using documented quality assurance procedures that meet WDNR procedures. Data submitters outside of WDNR are referred to EPA's site for questions on quality assurance project plans at https://www.epa.gov/quality.

Agencies and individuals submitting data for assessment purposes must: meet minimum data requirements, demonstrate that sample collection occurred at appropriate sites, during appropriate periods, and use certified laboratories for sample analysis. If the quality assurance procedures are not adequate, staff may use this data to initiate further investigations by Department staff. If quality assurance procedures are adequate, WDNR may use this data to assess the water for possible impairment listing.

WDNR may assist outside groups in the design and implementation of data quality procedures necessary for data to be used for assessments. Department staff will consult with EPA water quality criteria guidance, state WQS, and use professional judgment to interpret the results of field sampling to determine whether or not WQS are achieved. Groups outside of WDNR who regularly collect and submit data to WDNR may work with staff at Central Office to upload data into the SWIMS database to be considered as part of our evaluation and assessment process.

WDNR also supports Citizen Based Monitoring Programs for rivers, streams and lakes. As stated in the WDNR's Water Resources Monitoring Strategy for Wisconsin, "If citizens follow defined methodology and quality assurance procedures, their data will be stored in a Department database and used in the same manner as any Department-collected data for status and trends monitoring defined in the Strategy." Citizen data are currently used for general water quality assessments, including broad-scale statewide assessments. If these data indicate a potential water quality problem at a specific site, additional data may be collected by Department staff to verify the extent of the problem and determine if a waterbody should be placed on the Impaired Waters List.

2.3 Quality Assurance and Laboratory Analysis

Information used for assessments must be consistent with the WDNR Quality Management Plan or have been obtained using comparable quality assurance procedures. For all baseline monitoring supporting general and statewide assessments, quality assurance measures are described within each applicable chapter of the *Wisconsin DNR Water Division Monitoring Strategy*. WDNR uses only certified laboratories sample analysis, primarily the State Lab of Hygiene and the University of Wisconsin Stevens Point Aquatic Entomology Laboratory. For targeted, or special, monitoring studies which are frequently used to discern impairment prior to listing a waterbody, quality assurance protocols, such as field blanks, duplicates or spikes, are incorporated as funds allow.

2.4 Data Management

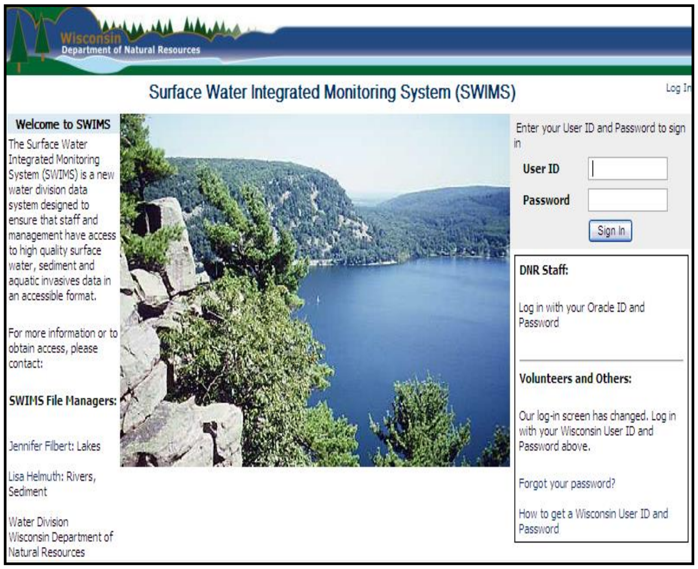
Well organized and readily accessible data is fundamental to a smooth functioning, scientifically grounded water quality monitoring and assessment program. The WDNR has invested many resources into building and maintaining monitoring and assessment databases.

Monitoring Data – SWIMS

The Surface Water Integrated Monitoring System (SWIMS) (Figure 2) is a WDNR information system that holds chemistry (water, sediment), physical (flow), and biological (macroinvertebrate, aquatic invasive) data.

SWIMS is the state's repository for water and sediment monitoring data collected for CWA work and is the source of data sharing through the federal Water Quality Exchange Network, which is an online federal repository for all states' water monitoring data. WDNR Fisheries and Water Quality Biologists use the system to document monitoring stations for both Water Quality and Fisheries Program datasets, providing a gateway to fisheries management datasets housed at the U.S. Geological Survey.

Figure 2. SWIMS database sign in screen.



The SWIMS database supports Citizen Based Stream Monitoring (CBSM) Level 2 Program volunteers. Level 2 volunteers come into the program with previous water monitoring experience, most volunteers having participated in the CBSM Level 1 Program (Water Action Volunteers or WAV Program). The Level 2 training focuses on the proper use of WDNR field methods and specialized equipment, such as transparency tubes, DO and pH meters. The Level 2 Program Coordinator trains volunteers to properly calibrate the instruments, use and store the equipment, record the data, etc. Volunteers chose monitoring locations on nearby streams with input from WDNR staff. The data collected by Level 2 volunteers are entered into the SWIMS database and quality assured by WDNR staff. SWIMS also supports the Citizen Lake Monitoring Network (CLMN) datasets, which are collected by citizen volunteers and used directly for lake general assessment work.

Assessment Data – WATERS

The Water Assessment, Tracking and Electronic Reporting System (WATERS) is an internal WDNR data system that includes the following water program items:

- Water Division Objectives, Goals, Performance Measures, and Success Stories;
- CWA Use Designations and Classifications (chs. NR 102 and 104, Wis. Adm. Code);
- Outstanding and Exceptional Resource Waters Designations (ch. NR 102, Wis. Adm. Code);
- CWA assessment data, including decisions about whether a waterbody is meeting its designated use or is considered "impaired";
- Impaired waters tracking information, including the methodology used for listing, the status of the Total Maximum Daily Load (TMDL) creation, and restoration implementation work;
- Fisheries Trout Classifications [s. NR1.02(7), Wis. Adm. Code];
- Watershed planning recommendations, decisions, and related documents.

2.5 Data Requirements

By establishing data requirements, WDNR staff collect representative data as efficiently as possible with limited staff and fiscal resources and use those data in a manner that minimizes the chance of incorrectly characterizing the attainment status of a particular water. Extremely large datasets are neither available nor necessary for many water bodies in the state. Minimum data requirements have been established for indicators including:

Period of Record: Generally, data from the most recent 10-year period may be considered when assessing waters to ensure that the data are representative of a wide range of factors that affect water quality (i.e., weather, flow) [4]. If staff determine that older data within the 10-year period are no longer representative of recent conditions, the period may be shortened to the most recent 5 years. To make such a determination department staff will consider whether significant changes at the watershed or local scale have occurred, such as changes in land use, nonpoint source controls, or the amount of pollutants discharged from point sources.

Table 1. Date range for data used each assessment cycle. This 10-year pattern is consistent back to the 1998 list.

Assessment Cycle	Period of Record (Data Date Range)	Assessment Cycle	Period of Record (Data Date Range)
2024	2013 – 2022	2010	1999 – 2008
2022	2011 – 2020	2008	1997 – 2006
2020	2009 – 2018	2006	1995 – 2004
2018	2007 – 2016	2004	1993 – 2002
2016	2005 – 2014	2002	1991 – 2000
2014	2003 – 2012	2000	1989 – 1998
2012	2001 – 2010	1998	1987 – 1996

Sampling Period: The WisCALM guidance document identifies the appropriate sampling period for each parameter and waterbody type. The determination of appropriate sampling period is based on seasonal variability in pollutant levels and corresponding ecological responses. Data from two sampling seasons will be needed for some assessments to account for sampling error or annual variation. Further parameter and waterbody specific details on sampling periods are included in sections 4.0 Lake Classification and Assessment Methods, 5.0 Stream & River Classification and Assessment Methods, and 6.0 Public Health and Welfare Uses Applicable to all Waterbody Types.

Representative Data:

- **Sampling Protocol**: Individual data points must have been collected according to parameter-specific protocols. Prescheduled sampling designs are often used for 305(b)/303(d)-related monitoring in order to randomly capture the range of conditions. In these cases, targeted samples that are collected for other purposes (e.g. monitoring targeted during runoff events) should not be incorporated into the 305(b)/303(d) assessment datasets. In other cases, weather and hydrologic conditions must match intended conditions specified in the sampling protocols. For example, biological samples should be collected during base flow, not following a runoff or scouring flow event, to ensure the sample is representative of normal conditions.

[4] Total phosphorus and biological data (chlorophyll-*a*, macroinvertebrates and fish) from the most recent 5-year period are used to make impairment decisions. However, if insufficient data are available from the most recent 5-year period, data collected within the past ten years may be used.

- **Extreme Weather Years:** Chemical and biological parameters are likely to be affected by extreme weather conditions. If a prescribed sampling schedule falls during an extreme weather year, exhibiting unusual average air temperature, precipitation, stream flow or water levels, a determination should be made as to whether that year was an extreme weather year that resulted in unrepresentative conditions. As a very general guideline, an extreme weather year may be defined as a year where precipitation, flow, stage/elevation, and/or temperature are above the 90th or below the 10th percentile of the annual averages within the period of record. Staff may use a combination of the following sources to document their determination of whether data were collected from a particular waterbody during an extreme weather year:
    - Climate data from nearest regional weather station(s);
    - Regional stream stage/flow gage(s);
    - Indices of drought severity (e.g., Palmer Drought Severity Index, U.S. Drought Monitor).

  If it is determined that a year was an extreme weather year resulting in unrepresentative conditions, that year's data points should not be excluded, but rather should be supplemented with data from an additional year of monitoring. In this case, combined data from a minimum of two years should be used for assessments to account for variability between years. Gaps in assessment datasets left when samples are determined to be unrepresentative should be filled by either collecting additional data or considering data from outside the standard period of record.

  Best professional judgment may be used to determine whether data were collected from an extreme weather year and are considered unrepresentative of normal conditions. For instance, a region may be experiencing drought, but stream flow may not be impacted significantly for those streams that are dominated by groundwater flows.

- **"Evaluated" Information:** Information that is not considered representative of current conditions or was not collected according to WDNR's Quality Management Plan cannot be used in preparation of the Impaired Waters List. WDNR classifies these types of data as "evaluated" information, which may include:
    - Information provided by groups, other agencies or individuals where collection methods are not documented and thus the data quality cannot be assured;
    - Projected surface water conditions based on changes in land use with no corresponding in-water data (i.e., desktop analyses or models);
    - Visual observations that are not part of a structured evaluation;
    - Anecdotal reports.

    Though not used directly to update the impaired waters list, "evaluated" data may potentially be used to identify areas where further monitoring may be needed for future assessment cycles.

- **Sample Type:** The indicator being evaluated will dictate what type of samples should be used for an assessment decision. In some cases, samples may be collected as instantaneous measurements vs. continuous measurements. In other cases, the choice may be between a grab sample and a composite sample. In either case, the selection of the values should result in using the most representative data available.

- **Sample Size**: This document outlines sample sizes that appropriately and efficiently represent existing and relevant conditions. Sample size requirements differ by water body type and parameter. The number of samples required is commensurate with the inherent sampling error and annual variation of the parameter measured. Available representative data should be reviewed to ensure that the minimum data requirements are met. However, a waterbody may be listed as impaired despite minimum sample size not being achieved if overwhelming evidence of impairment exists (see Ch. 7.2, Professional Judgment).

2.6 Assessment Unit Delineation and Grouping

Assessment units (AUs) represent the spatial area that data can be associated with for the purpose of categorizing a waterbody or developing management goals. Data collected within an assessment unit's boundaries may be compared when determining the health of a waterbody. When working on a project for a specific waterbody, such as assessing its monitoring data or developing a TMDL, it may be necessary to split an existing AU or beneficial to group multiple AUs for efficiency and practicality.

The following are guidelines for DNR staff to consider when determining breakpoints between AUs and AU groupings:

Existing TMDL breakpoints
Before grouping AUs, check to see if there is an existing TMDL in place. If so, try to match the breakpoints used in the TMDL, if feasible. This will avoid future difficulties with TMDL implementation on these segments.

Change in Natural Community classification and/or codified designated uses
Natural Communities (NCs) are assemblages of specific plant and animal species within a specific habitat. A waterbody's NC determines the type of assessment done. Stream NCs are based on temperature and flow, which are important grouping factors. However, the modeled NCs and codified designated uses are not continuously updated, so be sure to use any additional data or professional judgment when combining AUs. Other pertinent classifications may also be considered, such as trout fishery classifications.

- EXAMPLE: As appropriate, combine all adjacent AUs with a common NC classification; but if the NC has not been verified and is suspected to be incorrect, then take that into account in the decision to combine the AUs.
- EXAMPLE: NC verification shows a current AU has two different NCs, which means one portion is not representative of the other. This AU is a candidate for splitting.

Change in flow or assimilative capacity of waterbody
Flow is important because it impacts assimilative capacity, a waterbody's ability to carry pollutants without adverse impacts. Compliance points are also often determined just upstream of major changes in flow or assimilative capacity.

- EXAMPLE: Where a significant tributary joins a stream; or where a permittee's discharge significantly changes the flow or the concentration of the pollutant of concern.

Change in criteria
Consider establishing a breakpoint if the assessed pollutant's criteria changes.

- EXAMPLE: A stream's Total Phosphorus (TP) criterion changes from 75 µg/l to 100 µg/L; a stream flows into a lake with a lower criterion; a site specific criterion has been established; or there are variances to water quality criteria (such as listed in Ch. NR 104 Wis. Adm. Code).

Major Land Use changes
Using best professional judgment, consider land use changes that may alter the pollutant load or habitat being assessed.

- EXAMPLE: Major change in farming practices; rural to urban changes.

Avoid splitting existing multipart segmentation of the WDNR's 1:24,000 scale geospatial dataset
In determining where an AU grouping should end, try to match the breakpoint to the existing extent of a geodatabase hydrolayer segment, if possible. Hydrolayers can be viewed on the Surface Water Viewer.

Best Professional Judgment
Use professional judgment to account for other natural habitat changes or anthropogenic modifications that might be unique to the water being assessed.

- EXAMPLE: Major stream bed changes (e.g., from gravel to silt, or natural to concrete)

3.0 The Assessment Process: An Overview

3.1 General Condition Assessment

Data collected under WDNR's stratified monitoring strategy are used to begin assessing whether a waterbody is attaining its assigned designated uses. A general condition assessment can be done with biological and water quality metrics but is only considered a general assessment because there is insufficient data for a full impairment assessment. Minimum data requirements for each assessment type are available throughout this document.

WDNR uses four levels of biological conditions to represent water's placement in the overall water quality continuum:

- *Excellent*- Waters are considered to be fully supporting their assessed designated uses.
- *Good or Fair*- Waters are considered to be supporting their assessed designated uses.
- *Poor*- Waters may not support assessed designated use(s) but have insufficient information for a decision at the impairment assessment level.

Waters meeting criteria for water quality metrics, which include temperature, total phosphorus, and chloride, are considered attaining their assessed designated uses. Waters where a water quality metric exceeds criteria are potentially not meeting their assessed designated uses, but there is insufficient information for an attainment decision.

Waters determined to be in poor condition or exceeding criteria based on a limited amount of monitoring data are further evaluated and may be selected for additional monitoring or, if the limited dataset includes overwhelming evidence of impairment (e.g. large magnitude of exceedance), might be considered for Wisconsin's Impaired Waters List based on best professional judgment (see section 7.2).

3.2 Impairment Assessment

The assessment of whether a waterbody is meeting designated uses requires comparison to applicable water quality criteria, or, when numeric criteria do not exist, a well-defined reference condition or listing thresholds as a benchmark for comparison to narrative standards.

This section briefly outlines the concepts of indicators and associated thresholds to measure attainment status of Wisconsin lakes, rivers, and streams. For purposes of this guidance, the term "indicator" is used to describe the various measures of water quality, including those that represent physical, chemical, biological, habitat, and toxicity data. The term "threshold" is used when referring to the numeric value or narrative description that distinguishes attainment of the WQS versus values that indicate impairment. In the simplest sense, a waterbody is defined as "impaired" when it is not meeting WQS, including its assigned designated uses.

Key Indicators for Assessments

Detailed assessments are tailored to the specific characteristics of a waterbody. Some assessments will focus upon one key indicator only, whereas others use multiple indicators. Furthermore, a stepwise process of indicator selection may be employed. For example, for assessment of total phosphorus impacts in cases of moderate enrichment, available biological information will be used to determine aquatic life use impairment and place the water in the proper reporting category. However, if phosphorus levels are exceedingly high, biological indicator data are not needed to determine impairment (i.e., the biological impairment is assumed). Assessment indicators are sub-divided into the following categories:

- Conventional physical-chemical
- Toxicity
- Biological

Impairment Thresholds

Impairment thresholds are applied to determine whether waterbodies should be placed on the Impaired Waters List. These thresholds are usually expressed as ambient water concentrations of various substances based on numeric water quality criteria included in chs. NR 102-105, Wis. Adm. Code, WDNR technical documents, and federal guidance (document links found in 10.0 Quick Link Guide). In some cases, qualitative thresholds based upon narrative standards may be used to make impairment decisions. In those cases, a thoroughly documented analysis of the contextual information should be used in conjunction with professional judgment to collectively support a decision. Impairment thresholds outlined in WisCALM guidance must be in line with the intent of the water quality criteria in code. In some cases, WisCALM lists impairment thresholds for parameters for which water quality criteria have not been promulgated (e.g., macroinvertebrate and fish indices of biotic integrity and chlorophyll concentration) that may also be used as guidance for impairment listing decisions.

For some assessments methods, a single criterion or threshold may not be applicable across all the different waterbody types. For assessments of waters against the statewide total phosphorus criteria, for example, an initial waterbody classification analysis is required to ensure the assessment process applies the correct criteria. For other assessment methods, the WDNR applies the same water quality criterion or threshold across all resource types. An example is the use of the same fish tissue mercury concentration for all our lakes and rivers in the assessment of Fish Consumption Advisories as part of the Public Health and Welfare Use (Chapter 6.1).

Exceedance Frequency

In the context of numeric water quality criteria, exceedance frequency refers to the number of times a criterion may be exceeded over a period of time before the water is no longer attaining the criterion and is considered impaired. Allowable exceedance frequencies for criteria contained in Wis. Adm. Code, are outlined in this WisCALM document in the assessment requirements for each parameter. In addition, allowable exceedance frequencies for some water quality or biological thresholds that are not included in Wis. Adm. Code are provided in the Lakes and Rivers/Streams chapters.

3.3 Water Quality Condition Categories and Lists

An assessed waterbody is placed into one of 5 condition categories, also known as integrated report (CWA 305(b)) categories (Figure 3). Waterbodies with insufficient data for a full assessment or ambiguous assessment results where a determination cannot be made are placed in Category 3. Waterbodies where all designated uses have been assessed and found to be supporting are placed in Category 1. Waterbodies where at least one designated use is attained, and no use is impaired, are placed in Category 2. Waterbodies can be placed in categories 2 or 3 based on general or impairment assessments.

Waters with impairments are placed in either category 4 or 5 depending on whether a cleanup plan (TMDL or alternative) has been approved by the EPA. Each of these categories has subcategories to further define the type of listing. Category 4 waters, also referred to as Wisconsin’s Restoration Waters List, are subcategorized by cleanup plan (Table 2). Waters on the Impaired Waters List are those in category 5 and are subcategorized by pollutant, source, or cleanup plans (Table 3). Further description of these categories and listings can be found in 8.0 Integrated Report Listing Categories.

Figure 3. Categorization of waterbodies based on water quality assessments. Categories 1 – 5 align with EPA's CWA 305(b) reporting categories. Impaired waters are defined as those in category 5, which is consistent with all states. Wisconsin defines category 4 waters as its Restoration Waters List and waters in categories 1 and 2 as its Healthy Waters List.

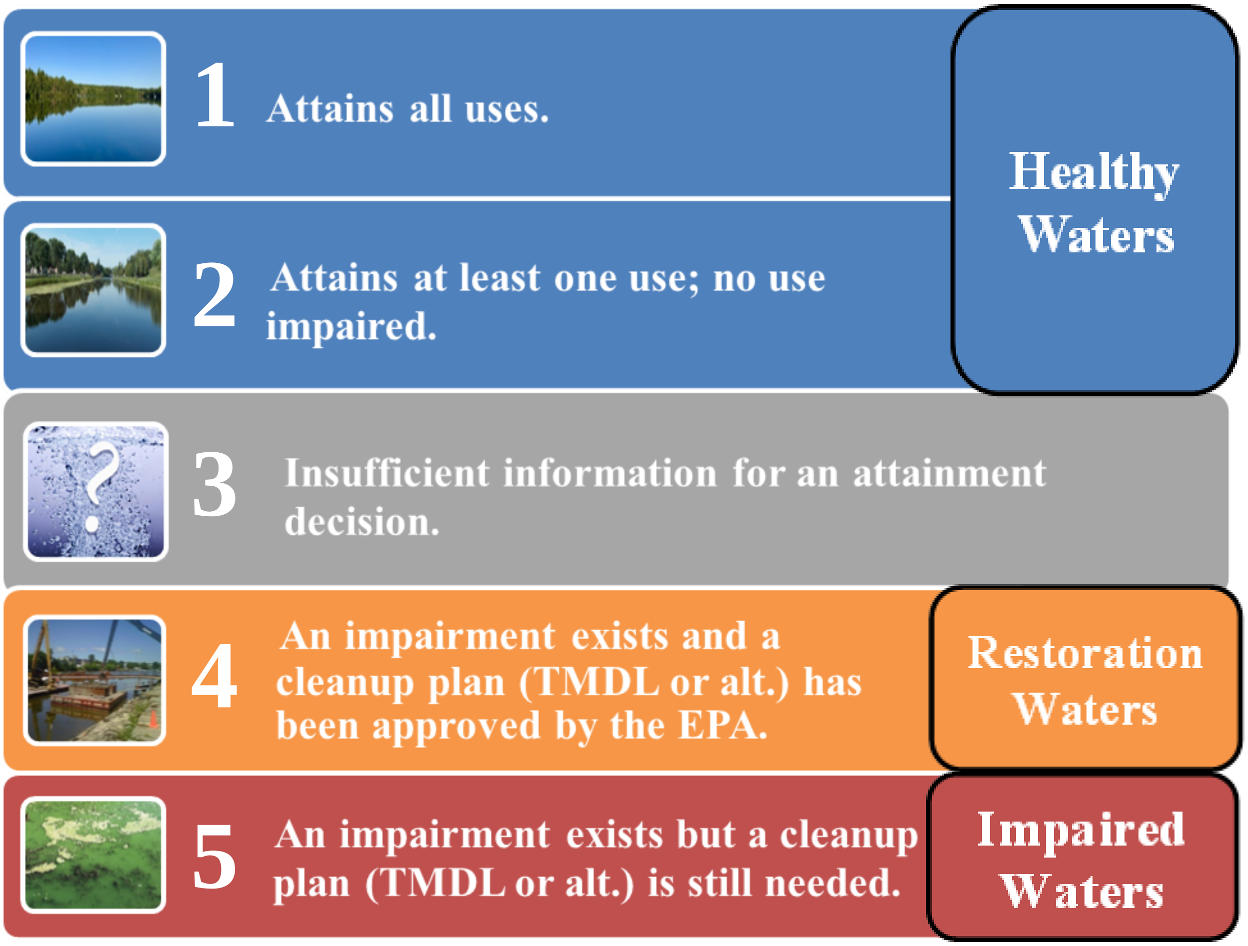


Table 2. Description of category 4 subcategories. These subcategories are based on those outlined by the EPA. Waters in category 4 are on Wisconsin's Restoration Waters List because a TMDL or alternative restoration plan has been created and approved by the EPA.

Sub-category	Description	Key Defining Factor
4A	A State developed TMDL has been approved by EPA or a TMDL has been established by EPA for any segment-pollutant combination.	TMDL approved by EPA.
4B	Other required control measures are expected to result in the attainment of an applicable water quality standard in a reasonable period of time.	Alternative to TMDL approved by EPA.
4C	The non-attainment of any applicable water quality standard for the segment is the result of pollution and is not caused by a pollutant.	No pollutant.

Table 3. Descriptions of category 5 subcategories. These subcategories are loosely based on ones outlined by EPA but are specific to Wisconsin. All waters in category 5 are part of the state's Impaired Waters List, also known as the CWA 303(d) List.

Sub-category	Description	Key Defining Factor
5A	Available information indicates that at least one designated use is not met or is threatened, and/or the anti-degradation policy is not supported, and one or more TMDLs are still needed. This is the default category for impaired waters.	TMDL needed. Default subcategory.
5B	Available information indicates that atmospheric deposition of mercury has caused the impairment and no other sources have been identified.	Mercury only.
5C	Available information indicates that non-attainment of water quality standards may be caused by naturally occurring or irreversible human-induced conditions.	Natural or irreversible conditions.
5P	Available information indicates that the applicable total phosphorus criteria are exceeded; however, biological impairment has not been demonstrated (either because bioassessment shows no impairment or because data are not available).	Phosphorus only.
5W	Pollutant/impairment a low priority for a TMDL because the impaired water is included in a watershed area addressed by at least one of the following WDNR-approved watershed plans: adaptive management plan, adaptive management pilot project, lake management plan, or Clean Water Act Section 319-funded watershed plan (i.e., nine key elements plan).	Alternative cleanup plan.

4.0 Lake Classification and Assessment Methods

4.1 Lake Classification

WDNR classifies or groups similar lake types based upon physical data. Specifically, lake size, stratification characteristics, hydrology and watershed size are identified as the primary influences on a lake and, to a large degree, these characteristics determine the natural biological communities each lake type supports. Using this information, lakes should fall into one of ten natural community types (Table 4).

Table 4. Lake and reservoir natural communities and defining characteristics.

Natural Community	Stratification Status	Hydrology
Lakes/Reservoirs <10 acres		
• Small	Variable	Any
Lakes/Reservoirs ≥10 acres		
• Shallow Seepage	Mixed	Seepage
• Shallow Headwater		Headwater Drainage
• Shallow Lowland		Lowland Drainage
• Deep Seepage	Stratified	Seepage
• Deep Headwater		Headwater Drainage
• Deep Lowland		Lowland Drainage
Other Classification (any size)		
• Spring Ponds	Variable	Spring Hydrology
• Two-Story Fishery Lakes	Stratified	Any
• Impounded Flowing Waters	Variable	Headwater or Lowland Drainage

The WDNR recognizes that lakes may vary geographically. Spatial data are available for each of the lakes. Regional differences in soils, climate and land use may explain additional variation in the bio-indicator metrics used in the classification of lakes[5]. However, WDNR has determined that lake size, hydrology and depth are more critical factors for initial classification of lakes, and that regional differences are secondary.

For most lakes, the WDNR's automated data packages determine which natural community and which impairment thresholds are appropriate based on the parameters described below. However, if the biologist has information to suggest that a lake's automatically assigned natural community is inaccurate or not representative of the lake, a change to the natural community may be made if reasons for the change are documented. If a Partial Lake Listing is being considered, a different Natural Community may be assigned to the portion of the lake being considered for a Partial Lake Listing, based on site characteristics that are significantly different from those in the rest of the lake.

Reservoirs – Reservoirs are classified using the same classification schema as lakes, described below, though biologists may employ multiple sampling stations on reservoirs to provide more representative data. NR 102.06(2)(f) of Wis. Admin. Code defines a reservoir as "a waterbody with a constructed outlet structure intended to impound water and raise the depth of the water by more than two times relative to the conditions prior to construction of the dam, and that has a mean water residence time of 14 days or

[5] Past Wisconsin studies have used eco-regions to explain landscape variability and EPA has proposed using this framework for assessment (Omernik 1987).

more under summer mean flow conditions using information collected over or derived for a 30 year period."

Size: Small vs. Large – Lake classification begins by first separating lakes into those 10 acres and greater and those less than 10 acres.

Small Lakes – Lakes less than 10 acres are classified into the Small Lake community. These lakes are uniquely different from communities in larger lakes but there is limited monitoring data available in Wisconsin. Because data for lakes less than 10 acres is so limited, it is difficult to set quality thresholds for assessment. Currently, there are very few thresholds set for water quality, fisheries, or aquatic plants for lakes less than 10 acres[6]. To address these small lakes in the future, Wisconsin may look to emerging wetland assessment tools for guidance.

Large Lakes – Lakes 10 acres or more are classified as Large Lakes. Large Lakes are further subdivided, by stratification status, hydrology, and watershed size, as shown below.

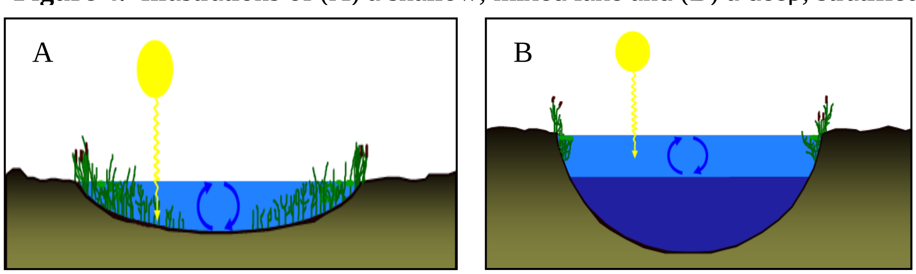
Stratification Status: Shallow (Unstratified or Mixed) vs. Deep (Stratified) – Lakes that are 10 acres or greater may be further characterized by their tendency to mix or stratify thermally. Stratification is an important factor in determining overall lake water quality and availability of suitable habitat for fish and aquatic life. An equation developed by WDNR Researchers (Lathrop and Lillie, 1980) is used by WDNR to identify whether a lake is categorized as Deep (Stratified) or Shallow (Unstratified or Mixed)[7]. Although this model is used to automatically generate lake classifications from the WDNR database, use of field data on depth, area, residence time, and temperature profiles to refine the model-based lake classifications is encouraged.

The Lathrop/Lillie equation is represented by a ratio calculated as follows:

$$\frac{\text{Maximum Depth (meters)} - 0.1}{\text{Log 10 Lake Area (hectares)}} \quad \text{or} \quad \frac{\text{Maximum Depth (feet)}*0.3048 - 0.1}{\text{Log 10 (Lake Area (acres)}*0.40469)}$$

Shallow (Unstratified or Mixed) – When using the Lathrop/Lillie Equation, any value less than or equal to 3.8 predicts a mixed lake, which is placed in the Shallow category (Figure 4A). Mixed lakes (Figure 4B) tend to be shallow, well-oxygenated, and may be impacted by sediment re-suspension. In addition, shallow lakes have the potential to support rooted aquatic plants across the entire bottom of the lake (Figure 4A).

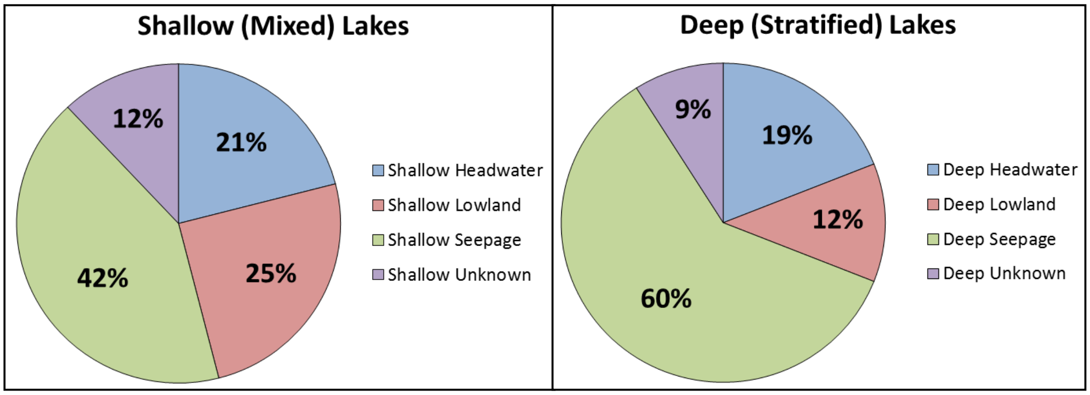
Figure 4. Illustrations of (A) a shallow, mixed lake and (B) a deep, stratified.



[6] Total Phosphorus criteria apply to lakes of five acres and larger.
[7] WDNR's decision to use the Lillie/Lathrop equation to determine stratification status also examined several other models for predicting lake stratification based on depth and area. These included work by Emmons et al. (1999), the Osgood Index (Osgood 1988), a Minnesota "lake geometry ratio" (Heiskary and Wilson 2005) and a model by WDNR Researchers (Lathrop and Lillie, 1980). The Lathrop/Lillie Equation was selected because it better distinguishes between clearly stratified and mixed lakes.

Deep (Stratified) –When using the Lathrop/Lillie Equation, any value greater than 3.8 predicts a stratified lake, which is placed in the Deep category. Stratified lakes tend to be deep, with a cold-water refuge for fish, and the potential for anoxic conditions (without oxygen) in the bottom layer which may release nutrients from sediments into the water column. Aquatic plants are typically confined to shallow (littoral) waters around the perimeter of the lake (Figure 4B). Stratified lakes exhibit thermal layering throughout the summer or they undergo intermittent stratification.

Figure 5. Distribution of Shallow and Deep lake types (for lakes greater than 10 acres).



*For unknown lake types a piece of information, like watershed size, is missing.

Hydrology and Watershed Size – Lake hydrology is the measure of the relative inflow/outflow of surface water compared to direct precipitation and groundwater inputs. Lake hydrology and lake watershed size are two other critical factors in lake classification. Both Deep and Shallow Lakes are further divided based on hydrology. The terms "seepage" or "drainage" are best used to describe the appropriate hydrologic category for lakes.

Seepage Lakes – A lake with no surface water inflow or outflow is considered a seepage lake (Figure 6). A seepage lake receives water from two sources: primarily from precipitation, both as overland sheet flow to the lake and directly onto the lake and seepage into the lake from groundwater. Seepage lakes tend to have lower nutrient concentrations, due to relatively small catchment areas, and may be poorly buffered against acid deposition.

Drainage Lakes – A lake with surface water inflow/ outflow from a river or stream is classified as a drainage lake (Figure 6). Drainage lakes tend to have more variable water quality and nutrient levels, depending upon the amount of land area drained by the lake's watershed. For this reason, watershed size also plays a key role in the classification of Drainage Lakes (Emmons, et al, 1999). Drainage lakes are subdivided by watershed size as follows:

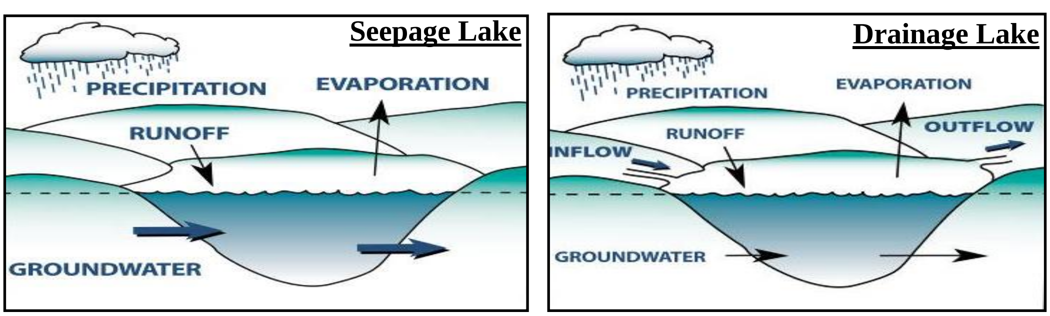


Figure 6. Hydrology of a seepage lake versus a drainage lake.

- <u>Headwater Drainage Lakes:</u> If the watershed draining to the lake is less than 4 square miles, the lake is classified as a Headwater Drainage Lake.

- Lowland Drainage Lakes: If the watershed draining to the lake is greater than or equal to 4 square miles, the lake is classified as a Lowland Drainage Lake.

Other Classifications (any size) – Three other classes representing unique natural communities are recognized in this classification scheme: Spring Ponds, Two Story Lakes, and Impounded Flowing Waters.

Spring Ponds –Spring ponds typically contain cold surface water and support coldwater fish species and are most often shallow headwater lakes. In order to be included in this category there should be documentation of a current or historical cold-water fishery (e.g., stream trout) and evidence of spring hydrology.

Two Story Fishery Lakes – Two-story fishery lakes are often more than 50 feet deep and are always stratified in the summer. They have the potential for an oxygenated hypolimnion during summer stratification and therefore the potential to support coldwater fish species in the hypolimnion. In order to be included in this category, a lake should meet the definition of "stratified" (Lathrop/Lillie equation value >3.8), be greater than five acres, and support a coldwater fishery. Supporting a coldwater fishery may either be demonstrated through documentation of a current or historical native cold-water fishery (e.g., cisco, lake trout), or verification with DNR fisheries biologists that the lake is on a long-term stocking plan for coldwater species, where the individuals have good year-to-year survival.

Impounded Flowing Waters—Rivers or streams that are impounded but do not meet the definition of reservoir above are considered to be "impounded flowing waters." Impounded flowing waters are lotic in nature and should be evaluated using the river and stream criteria that apply to the primary stream or river entering the impounded water. Biological response metrics may also include metrics that are typically used for lakes, such as chlorophyll-*a*, as deemed appropriate based on professional judgment.

4.2 Selecting Representative Stations

Station Locations: Selecting representative stations for assessment

Station selection is determined by the regional DNR biologist. For the majority of lakes a single "Deepest Spot" station has been selected for use in the automated assessment packages. If more than one station is designated in SWIMS as "Deepest Spot," the packages will use both. Biologists can change which stations the package utilizes by using the checkbox in WATERS under "Use for Assessment Pkgs?" (Figure 7). They can select and unselect stations as needed to appropriately characterize the site.

Stations

Previous 31-40 of 45 Next

Station ID	Station Name	Water Body	WBIC	Use for Assessment Pkgs?
10017445	Lake Mendota -- Governors Island	Lake Mendota	805400	☐
10017444	Lake Mendota -- Warner Park	Lake Mendota	805400	☐
10017443	Lake Mendota -- Spring Harbor	Lake Mendota	805400	☐
10017429	Lake Mendota -- Tenney Park Boat Ramp	Lake Mendota	805400	☐
133464	Lake Mendota -- Middleton Boat Ramp	Lake Mendota	805400	☐
133318	Lake Mendota - Central Deep Hole	Lake Mendota	805400	☑
10041684	Lake Mendota Veith Ave. Carry In Access	Lake Mendota	805400	☐

Figure 7. Selection of representative stations in WATERS under 'Monitoring and Listing'. Access to WATERS is only available to DNR staff.

Lakes with multiple stations: Reservoirs, multi-lobed lakes, and very large lakes may not have a Deepest Spot station and/or may need more than one sampling station to accurately characterize the lake's morphology and to assess the lake. In these cases, to determine which stations should be selected to use for assessments, use the following guidelines:

- Typically, between two and five stations would be chosen to be representative of lake conditions, depending on the size and character of the lake.
- Select only 'active' stations that have data from within the past ten years.
- If there are stations that seem to be duplicative of the same location, contact SWIMS/WATERS support staff to determine whether those stations should be consolidated.
- For **very large lakes** (Figure 8), select well-spaced stations representative of the entire lake.
- For **reservoirs/flowages** (Figure 9), select stations that are roughly equally spaced along the thalweg (the deepest channel along the river line). Stations in flowing portions near the upstream entry point of the river may be eliminated.
- For **lobed lakes**,
  - if there are **multiple deepest spots** (Figure 10), select a station for each deep spot.
  - if there is **one deepest spot** but it is not representative of the entire lake (Figure 11) select the deep spot as well as other stations to represent the other portions of the lake. It may be more difficult in these situations to determine which stations provide the best representation of the lake.

Once the biologist has selected which stations will be used to assess the lake, the additional stations should be indicated in WATERS. To do this, check the checkbox to the right of each station you wish to select[8]. These stations are then automatically represented in the TP and chlorophyll-*a* Package results.

For lakes with multiple stations selected, the assessment results for each station will be shown individually.

Note: The maps below are for illustrative purposes only; the stations shown may not be the most representative stations available.

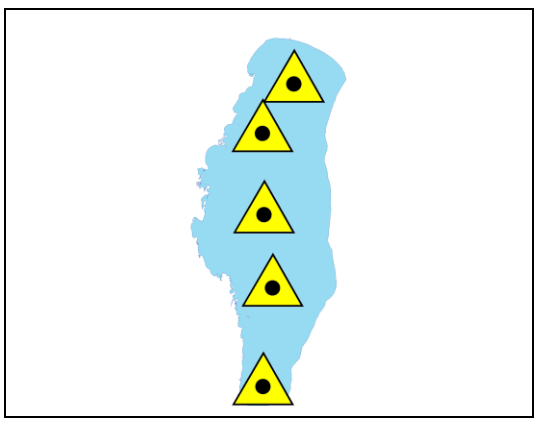


Figure 8. Large Lakes: Select well-spaced stations throughout lake. Example: Lake Winnebago

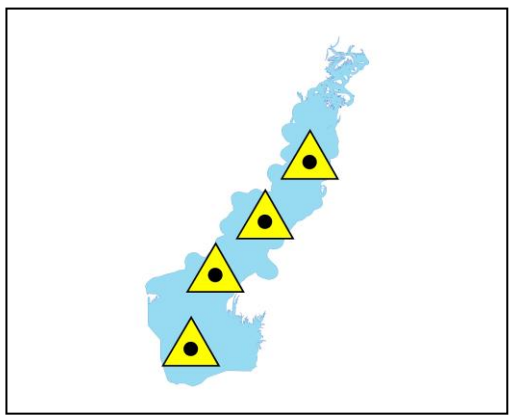


Figure 9. Reservoir/Flowages: Select stations along the deepest channel. Example: Lake Petenwell, Juneau County

[8] Data packages are updated every Friday evening. If new stations are selected, the biologist will need to re-run the packages the following week to incorporate the new information.

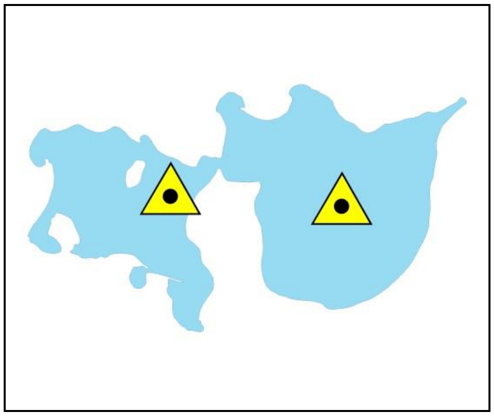


Figure 10. Lobed Lakes with multiple deep holes: One station per deep hole.
Example: Two Sisters Lake, Oneida County

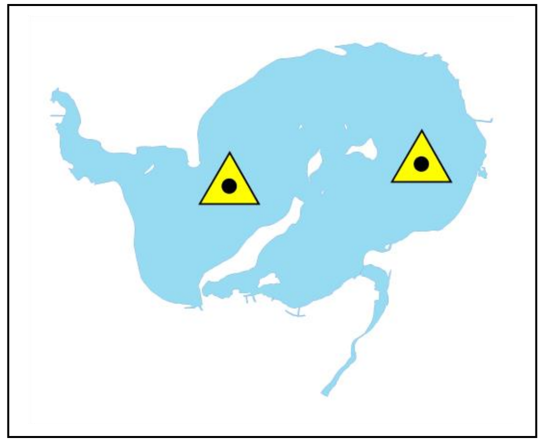


Figure 11. Lobed Lakes with one deep hole: Use Deep Hole station and another station representative of shallower area.
Example: Fox Lake, Dodge County

Whole Lake vs. Partial Lake Assessment

As a rule, a lake is a mixed system that functions as a single, contiguous unit. Therefore, in the vast majority of situations where there are multiple stations used for assessments, if one station is impaired on the lake, the whole lake would be listed as impaired. However, in cases where a known or suspected localized pollution source is believed to cause impairment in only one portion of a lake (such as an isolated bay or well-defined lobe), biologists may consider assessing and listing that portion as impaired separate from the larger lake.

In cases where Partial Lake Assessments and/or Partial Lake Impairment Listing are warranted, the portion of the lake under consideration should be delineated as a separate Assessment Unit to differentiate it from the larger part of the lake. This is typically warranted when the geography of the lake is such that there is a physical barrier separating most of one portion of the lake from the main portion. In such cases, the partial lake area will typically be assigned its own Natural Community, which may differ from the greater lake.

For Partial-Lake assessments, a sampling station should be added that is representative of the partial-lake area. Such a station should be situated in open water, so that samples are not taken near-shore or in an effluent plume but in ambient lake water within the vicinity of the suspected source of the problem.

Partial Lake Impairment Listings

In cases where a localized pollution source is believed to cause impairment in only one portion of a lake, as evidenced by a station's exceedance of an impairment threshold in only one area of a lake, biologists may consider listing only that portion of the lake as impaired using the appropriate Natural Community threshold. However, if, for instance, one area of a lake is experiencing high algae concentrations due to algae that are being produced throughout the lake but are blown by the wind to a particular area, this would be considered a whole lake problem and partial lake listing would not be appropriate.

4.3 Lake General Condition Assessment

The WDNR focuses on in-lake water quality metrics to assess a specific lake's Aquatic Life designated use. These in-lake parameters correlate strongly with fish and other aquatic life communities (e.g., macroinvertebrates, aquatic plants, etc.) within a lake.

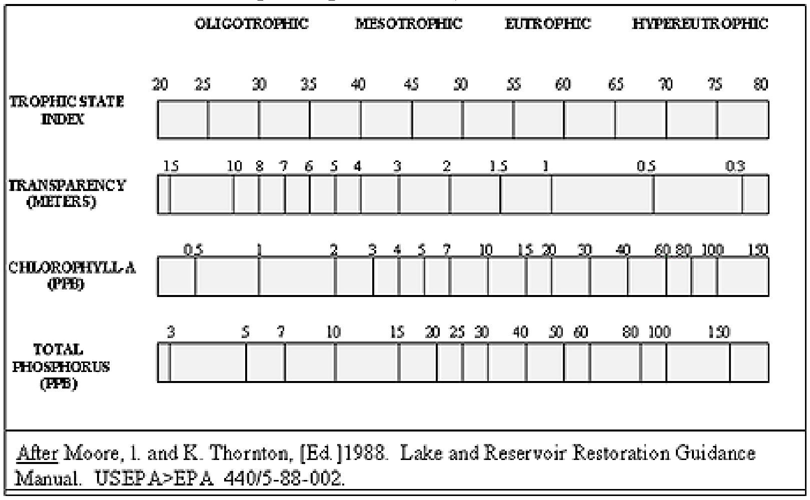


Figure 12. Continuum of lake trophic status in relation to Carlson Trophic State Index.

Wisconsin bases its General Condition Assessment for lakes on the multiple metrics including the Carlson Trophic State Index (TSI) (Carlson, 1977), water chemistry, and physical measures.

Carlson Trophic State Index (TSI)

The Carlson TSI is the most commonly used index of lake productivity. It provides separate, but relatively equivalent, TSI calculations based on either chlorophyll-*a* concentration (chlorophyll-*a*, or CHL in the equation below) or Secchi depth (SD, for which Wisconsin also uses satellite clarity data as a surrogate)[9]. Because TSI is a prediction of algal biomass, typically the chlorophyll-*a* value is a better predictor than Secchi or satellite data. Water clarity as measured by Secchi depth or satellite is a practical measure of algal production and water color. Algal production is known to be highly correlated with nutrient levels (especially phosphorus). High levels of nutrients can lead to eutrophication and blue-green algae blooms. This limits the amount of available light to macrophytes and adversely affects other aquatic organisms. Information from each of these parameters is valuable because the interrelationships between them can be used to identify other environmental factors that may influence algal biomass.

TSI values range from low (less than 30), representing very clear, nutrient-poor lakes, to high (greater than 70) for extremely productive, nutrient-rich lakes (Figure 12). Very few lakes in Wisconsin would fall into the category of "very clear, nutrient poor lakes." The cutoff for excellent TSI values would certainly include these lakes (Table 5) but also includes some lakes in the mesotrophic category, based on sediment core data which indicates that some lakes are naturally more productive than others.

Data requirements
TSI is automatically calculated using a programming package (TSI Package) that draws from Department data in SWIMS. The rules used by the TSI Package are described below. These requirements are set to provide enough data to account for the average lake condition during the summer index period (when the lake responds to nutrient inputs and achieves maximum aquatic plant growth) over several years to account for unusual weather (dry, wet, hot, cold).

a) *Seasonal Range and Sampling Frequency.*

- For chlorophyll-*a* and Secchi data, the TSI Package requires 2 samples per year in each of 3 different years. Samples should be collected between July 15 – September 15.

[9] Carlson also provides an equation to convert total phosphorus concentration to TSI, but WDNR is not using that equation for purposes of water quality assessments or 303(d) Impaired Waters Listing.

- For satellite clarity data, at least one satellite inferred clarity reading is required in each of 3 years (3 values minimum). Samples should be collected between July 1 – September 30.

b) *Sampling Depth.* Chlorophyll-*a* samples taken from the top 2 meters of the lake will be used to calculate TSI (excluding grab samples collected at 0 m). Samples can be grab samples or integrated samples.

c) *Year Range.* Sampling data are used from within the most recent 5 years (2008-2012).

d) *Sampling and Analytical Methods.* Field collection, preservation and storage should follow procedures outlined in the WDNR Field Procedures Manual and the Citizen Lake Monitoring Manual (http://dnr.wi.gov/lakes/CLMN/manuals/). Laboratory analysis should follow standard methods (WSLH 1993). Data collected using different protocols may be considered, with limitations, based upon professional evaluation.

Calculations

a) For each year with sufficient data, first all values are converted to TSI using the calculations below (calculate TSI *separately* for chlorophyll-*a*, Secchi, and satellite data)[10]. (Note: Satellite readings are automatically converted to clarity values (equivalent to Secchi depth) in SWIMS.)

TSI_{CHL} = 9.81 ln (CHL) + 30.6
TSI_{SD} = 60 – 14.41 ln (SD) (satellite inferred clarity data can also be used in lieu of Secchi data in this equation)

Where:	TSI = Trophic Status Index	CHL = Chlorophyll-*a* concentration (µg/L)
	SD = Secchi depth (meters)	Ln = natural log

b) For each year of data, an Annual Average is calculated from the data points within that year (Annual Averages are calculated separately for each parameter).

c) All available Annual Averages from the last 5 years are averaged together, to produce a Multi-Year Average (Multi-year Averages are calculated separately for each parameter).

d) The TSI Package automatically prioritizes which TSI Multi-Year Average to use in comparison against the General Condition Assessment Thresholds. Historically, there has been a tendency to average the three TSI values, but research suggests that this generally is not a good practice (Carlson and Simpson 1996). Therefore, Wisconsin has instituted a prioritization system for selecting which TSI score to use. When more than one Multi-Year Average TSI score is available, whichever TSI score is based on the most direct measure of algal biomass will be used, as follows:

- TSI based on chlorophyll-*a* will be used if available, since this is the most direct measure of trophic state.
- TSI based on measured Secchi data is the second preference; Secchi depth readings measures clarity as a surrogate for trophic state.
- TSI based on satellite data is the third preference, as it infers water clarity rather than measuring water clarity directly.

e) The final step in the General Assessment is to compare the lake-specific Multi-year Average TSI value to the lake general condition assessment thresholds shown in Table 5. As described

[10] Although Carlson's Trophic State Index also provides a calculation for TSI based on total phosphorus (TP), Wisconsin does not calculate TSI based on phosphorus for General Condition Assessments. TP concentrations are used to determine whether a waterbody exceeds thresholds for 303(d) listing as a pollutant.

previously, the lake condition assessment thresholds establish four categories for each Lake Natural Community: Excellent, Good, Fair, and Poor.

Table 5. Trophic Status Index (TSI) thresholds – general assessment of lake Natural Communities.

Condition Level	Shallow			Deep			
	Headwater	Lowland	Seepage	Headwater	Lowland	Seepage	Two-Story
Excellent	< 53	< 53	< 45	< 48	< 47	< 43	< 43
Good	53 – 61	53 – 61	45 – 57	48 – 55	47 – 54	43 – 52	43 – 47
Fair	62 – 70	62 – 70	58 – 70	56 – 62	55 – 62	53 – 62	48 – 52
Poor	≥ 71	≥ 71	≥ 71	≥ 63	≥ 63	≥ 63	≥ 53

Note: Although TSI thresholds are not yet available for three natural communities: 1) Small Lakes; 2) Spring Ponds; and 3) Impounded Flowing Waters, by default assessments are completed for the most similar natural community for which thresholds are currently available.

Derivation of TSI General Condition Thresholds

TSI thresholds are used to place a lake into one of four general condition categories of excellent, good, fair, and poor. These thresholds are not codified as water quality standards and are not used for impairment assessments (i.e. to determine a use is not supported). However, TSI data may be used to determine that the Aquatic Life use is supported, and the lake may be assigned to integrated reporting Category 2 when the lake's general condition is fair or better and no other information is available to assess. The following describes the derivation of the TSI condition thresholds.

Excellent Condition

To establish the excellent range for TSI conditions, WDNR uses excellent or "reference" conditions inferred from total phosphorus (TP) values based upon preserved diatom communities from pre-settlement times found in lake bottom sediment cores.

Sediment cores measure fossilized diatom communities allowing a comparison of historical (pre-settlement) conditions and recent water condition. This allows the comparison of current water clarity measurements to historical conditions with changes represented by the changes in algae conditions over time. Diatoms are a type of algae containing siliceous cell walls that fossilize in lake sediments. Diatom taxa are known to prefer narrow ranges of water quality. Therefore, inferences about historical water condition can be made from fossilized diatom communities at the bottom of the sediment core. These inferred concentrations, when converted to TSI values using the Carlson equations, can be used as reference values. This approach will not work for most reservoirs, impounded flowing waters, or raised wetland lakes since these lakes are artificial and pre-settlement conditions do not exist. WDNR has not yet developed criteria specific to these artificially created waterbodies.

WDNR has sediment core data spanning each of the 6 natural lake community types (Table 6) and derives excellent TSI thresholds from these data (Garrison *et al*. 2008*). The transition between excellent and good for each natural community is based on the 75th percentile of the TSI values calculated from sediment core bottom inferred phosphorus concentrations.* The bottom sediment core values represent reference lake conditions and using the 75th percentile gives some margin for lakes to have changed since the bottom of the sediment core accumulated (Table 6).

Sediment cores are not available for small lakes or spring ponds and are not appropriate for impounded flowing waters. Since adequate sediment core data from two-story lakes is not available, the 75th percentile value for deep seepage lakes was used for the threshold between excellent and good condition (Table 5). Ideally, sediment core data should be collected whenever monitoring is conducted on two-story lakes.

Table 6. Mean and median inferred TP values calculated from top and bottom segments of sediment cores from 87 Wisconsin lakes (Garrison, unpublished data).

Lake Class	Natural Community	N	Mean TP (µg/L)		Median TP (µg/L)		75th Percentile (µg/L) (Bottom)	TSI Threshold
			Top	Bottom	Top	Bottom		
1	Shallow Headwater	17	27	24	26	19	30.3	53
2	Deep Headwater	19	24	18	21	14	20.5	48
3	Shallow Lowland	11	28	25	28	24	30.5	53
4	Deep Lowland	43	25	19	20	15	20.0	47
5	Shallow Seepage	15	17	16	16	14	17.0	45
6	Deep Seepage	29	15	13	12	11	15.3	43

Poor Condition

Setting the threshold for Poor Condition was approached differently for each lake type, as most appropriate for the specific conditions exhibited by those lakes:

> *Shallow Lakes:* The transition between a fair and poor condition for shallow lakes was set at a TSI of 71 (corresponding to TP concentration of 100 µg/L) because this approximates TP concentrations that lead to a switch from aquatic plant dominated to algal dominated ecosystems in shallow lakes (Jeppesen et al. 1990). This represents a major ecosystem change and once it occurs, it is very difficult to restore to the aquatic plant dominated state.
>
> *Deep Lakes:* The fair to poor transition threshold for deep lakes was set using a TSI value known to cause increased frequency of algal blooms, high amounts of blue-green algae and/or hypolimnetic oxygen depletion. A TSI of 63 (corresponding to TP of 60 µg/L) was chosen because it represents the threshold between eutrophic and hyper-eutrophic lakes (Carlson 1977).
>
> *Two-Story Lakes:* TSI values that cause significant hypolimnetic oxygen depletion should be used as the threshold for two-story lakes since this habitat component is critical for maintaining coldwater fisheries. This value will be highly dependent upon the lake's morphometry. Hypolimnetic oxygen demand is largely from the sediment; therefore, the greater the ratio of *sediment area to hypolimnetic water volume* the higher the hypolimnetic oxygen demand. That makes setting this threshold very difficult. A conservative TSI value of 53 (corresponding to a TP of 30 µg/L) is recommended. Further research on these relationships is needed to derive accurate values for two-story lakes.

Good and Fair Condition

The transition value between the condition of "fair" and "good" for each natural community was selected as a mid-point between the excellent and poor TSI values (Table 5).

Other Parameters

Any of the chemical, physical, and biological parameters assessed to determine lake impairment can also be used for a general condition assessment. Full impairment assessments require a minimum amount of data, but assessment methods can be applied to datasets that do not meet that threshold; results from these assessments are used for general assessments. An assessment resulting in attainment is considered attaining one or more uses. A general assessment that results in a parameter exceeding criteria is considered potentially not attaining (Table 7). Minimum data requirements for each parameter type and designated use assessment for lakes are outlined in the rest of section 4.

Table 7. General water condition assessment decisions based on biological and water quality metrics.

Metric		Assessment	
Biological Metrics (TSI*, mIBI, fIBI)	**Water Quality Metrics (TP, Temp., Chloride, etc.)**	**Designated Use Support**	**Attainment Decision**
Excellent	Meets Criteria	Fully Supports Use	Attaining
Good		Supports Use	
Fair			
Poor**	Exceeds Criteria**	May Not Support Use	Insufficient Information

*Secchi, chlorophyll, and satellite-based values.
**Not enough data to do a full impairment assessment.

General Assessment Categorization

Waters assessed at the general level are placed onto the Healthy Waters List or into Category 3 (insufficient information) (Figure 3). General assessments do not result in impairment listings unless a biologist demonstrates a reason for listing using their best professional judgment (Chapter 7.2 Professional Judgment). General condition assessments of 'May Not Support Use' (Table 7) result in the water being placed in Category 3 and are potential follow-up monitoring priorities. If all metrics support the use assessed then the water is placed in Category 1 or 2, also called the Healthy Waters List.

Waters that started in Category 2 but have a new general assessment metric that may not support the designated use will remain in Category 2 until an impairment condition assessment can be done or a decision is made based on best professional judgment.

4.4 Lake Impairment Condition Assessment

Not all waters categorized as Poor or Exceeding Criteria in the General Condition Assessment should be considered Impaired or warrant 303(d) listing. Whether or not a waterbody should be listed as impaired is dependent on the strength of the data used to make the assessment. To submit a lake for the 303(d) List, it should exceed certain numeric listing thresholds or meet narrative listing criteria. A General Condition Assessment status of "Poor" or "Fair" based on TSI score serves as a flag that TSI values and other parameters such as TP, temperature, DO, and pH should be evaluated against the additional impairment thresholds outlined in Table 10. In addition, best professional judgment may be needed for certain parameters (such as TSS and turbidity), or unique natural communities (such as two-story lakes or impounded flowing waters) for which there are currently no thresholds or criteria for certain parameters.

It is important to determine the relationship between the impairment and pollutant when placing a waterbody on Wisconsin's Impaired Waters List. There are a number of field-measurements that can be taken to more clearly define the condition of a lake and determine what specific impairments and pollutants may be present. Selecting the correct indicators is an important part of understanding the underlying causes of water quality problems. Collectively, the type of data collected and the frequency of sampling is critical for accurate listing and the development of a successful management strategy. Guidance on how to make attainment decisions for some of the more common pollutants or stressors observed in Wisconsin lakes is provided below.

4.5 Lake Impairment Condition Assessment: Aquatic Life (AL) Use[11]

Minimum data requirements and calculations for Pollutant and Impairment indicators
For all of the Lake Pollutant and Impairment Indicators, the following guidance on minimum data requirements apply for *Station Location, Year Range, Sampling and Analytical Methods,* and *Data Quality*. Guidance for frequency, seasonality, sampling depth, and any specific data quality notes are specific to different parameters and are provided under each Pollutant or Impairment Indicator. Some of the more common Pollutants and Impairments are described in the text below; these and others are also documented in Table 10.

Station Location. See section 4.2 Selecting Representative Stations.

Sampling and Analytical Methods. Field collection, preservation and storage should follow procedures outlined in the most recent version of the WDNR Lake Sampling Procedure document which can be found by searching in WDNR's guidance library (https://dnr.wi.gov/water/egadSearch.aspx, search term "lake sampling procedure") and the Citizen Lake Monitoring Manual (http://dnr.wi.gov/lakes/CLMN/manuals/). Laboratory analysis should follow standard methods (WSLH 1993). Data collected using different protocols may be considered, with limitations, based upon professional evaluation of data.

Data Quality. Sample points may be excluded if there are quality control concerns or if the data were collected for specific studies that are not representative of overall lake conditions. Quality concerns are determined by consulting the sampling methods used and/or the Quality Assurance Plan associated with the data.

Total Phosphorus (TP) and Chlorophyll-*a* [12]
Phosphorus is one of Wisconsin's most common pollutants for lakes. In 2010, Wisconsin developed numeric criteria for TP and corresponding protocols for listing waterbodies for TP as a pollutant. Algal biomass, as measured by chlorophyll-*a* concentrations, is one of the most common response metrics to increased phosphorus concentrations. For the purpose of assessing water quality against impairment thresholds, in-lake TP values and chlorophyll-*a* concentrations are calculated using automated programming packages that draw from Department data in SWIMS (these packages are referred to as the TP Package and Chlorophyll Package). The rules used by these packages are described below. Results from the packages are provided to biologists to use in their assessments; biologists may use professional judgment in assessing package results.

Any qualifying data from the period of record in the SWIMS database will be used, and the automated assessment package will provide statistical summary output whether or not the quantity of data points meets the assessment requirements. Including lake datasets that do not meet minimum requirements will allow biologists to review the available data and determine future monitoring needs. However, the automated assessment packages will indicate which stations do or do not meet the minimum data requirements for impairment assessment, and only those that do meet assessment requirements will be used for assessment reporting. Chlorophyll has separate thresholds for Recreation (REC) impairments and for Aquatic Life (AL) impairments. The REC TP thresholds, which are codified in ch. NR 102, Wis. Adm. Code, are used for both REC and AL. There are three, distinct packages that are run to report the needed calculations: TP REC & AL, CHL REC, and CHL AL. The calculations used are almost identical

[11] Aquatic Life Use was previously referred to as "Fish and Aquatic Life (FAL)". This was only a terminology change; no changes to the use definition were made.

[12] Heiskary, S, and C. B. Wilson, 2005. Minnesota Lake Water Quality Assessment Report: Developing Nutrient Criteria, Third Edition. Minnesota Pollution Control Agency, September 2005.

for TP REC & AL and CHL AL. These protocols are described below. The protocols for CHL REC are slightly different and are described in the Chapter 4.6. Once the package results are available, the TP and Chlorophyll results are assessed separately and *in combination with one another* to determine whether a lake should be listed as impaired, and if so, in what category. Because algae and aquatic plants are biological metrics that respond to phosphorus, they are used as biological confirmation of impairment related to phosphorus concentrations.

1. <u>Select data to use</u>

Period of record (for both TP & Chlorophyll-*a*)
Data from the most recent 10-year period may be used, but data from the most recent 5 years is given preference, as it is more representative of current conditions. See "**Select appropriate year range to use**" (below) for more detail.

Seasonal range and frequency
For official assessment purposes, the goal of the DNR's lake monitoring program will be to have 3 samples per year for both TP and chlorophyll-*a* that meet the data requirements outlined below.

- One sample per month should be taken during the designated sampling season. They should be taken as close as possible to the middle of the month.
- Samples must be spaced at least 15 days apart, to evenly represent the season.
- For TP, the allowable date range is June 1 – Sept. 15, allowing for four monthly samples (June, July, August, Sept.). Only three samples are needed for the calculations, but more samples will be used if available. For Deep (stratified) Lakes, samples from May and/or late September may be manually added if it can be demonstrated that the lake is thermally stratified during that time period.
- For chlorophyll-*a*, the target date range is July 15-Sept. 15[13], which should result in one sample for each of July, August, and September. However, if sampling within that window is not possible, data will be accepted if it is collected within one week of the sample season (i.e. July 8-Sept. 22).

Sampling protocols

- *Sampling and analytical methods:* Field collection, preservation and storage should follow procedures outlined in the WDNR Field Procedures Manual which is stored in the SWIMS system and the Citizen Lake Monitoring Manual. Laboratory analysis should follow standard methods (WSLH 1993). Data collected using different protocols may be considered, with limitations, based upon professional evaluation of data.
- *Sampling depth:* Only surface samples taken from the top 2 meters of the lake will be used (excluding grab samples collected at 0 m because these may contain a scum layer). Samples can be grab samples or depth-integrated samples. (If samples were taken from more than one depth within this zone at a single station on a single day, average the samples for that station for that day to produce the station's daily average.)
- *Data quality:* Sample points may be excluded if there are quality control concerns or if the data were collected for specific studies that are not representative of overall lake conditions. See Chapter 2.5 in WisCALM on *Data Requirements*.
- *Units:* Both TP and chlorophyll-*a* values should be expressed in µg/L. This is consistent with phosphorus water quality criteria in ch. NR 102, Wis. Adm. Code.

[13] The sampling periods for TP and chlorophyll-*a* are not identical. June samples are not used for chlorophyll-*a* assessments because many lakes have a clear water phase in June due to food web dynamics. Therefore, June samples do not appropriately represent lakes' summer chlorophyll-*a* conditions. However, for TP, June samples are included to reflect the range of summer conditions.

Aggregating samples and determining "qualifying years"

- *Calculate Daily Mean:* Most lakes will have only one sample per day within the correct depth zone (0-2 m or 0-6 ft); in these cases that single sample serves as the daily mean. If there is more than one sample from a single station on a single day from within the correct depth zone, then these samples should be averaged into one, and flagged. Samples with no depth or wrong depth should be excluded.
- *Determine "Qualifying Years"*[14]*:* A "qualifying year" is one that has at least 2 daily means that are in different months of the appropriate date range and that are at least 15 days apart. Whether or not a year is a qualifying year is indicated by the assessment package output.
- *Calculate Monthly Mean:* For all years, regardless of whether they are qualifying years, calculate the monthly mean from the daily means. Most lakes will have only one daily mean per month; in these cases that single value serves as the monthly mean. If more than one daily mean are available for a given month, average them into a monthly mean.

Number of samples required to meet assessment requirements

- For TP, a minimum of 6 monthly means over at least two qualifying years are required.
- For chlorophyll-*a*, the minimum number of monthly means and years required depends on whether the assessment is being used as a 'biology only' (i.e., standalone) impairment listing for chlorophyll-*a*, or whether it is being used in conjunction with TP for an impairment listing.
  - For a listing based on biology only (chlorophyll-*a*) exceedances, a minimum of 6 monthly means over at least two qualifying years are required.
  - For listing based on chlorophyll-*a* and TP exceedances, a minimum of 3 chlorophyll-*a* monthly means from at least one qualifying year is required.
- If three monthly means during a year are not available, multiple years may be used to assemble the minimum number of data points.

Select appropriate year range to assess

- All data (that meets requirements for depth/dates/etc.) from the most recent 5 years will be used. If there are enough monthly means within the most recent 5 years to meet minimum data requirements (6 monthly means over at least 2 qualifying years), then only the most recent 5 years will be used.
- If there are not enough monthly means within the most recent 5 years to meet minimum data requirements, then the data package will go back year by year (up to 10 years) to include more months until the minimum data requirement is met, and then stop (i.e. will not use any additional months from the 5-10 year range once minimum data requirement is met).
- If there are not enough months with data from the whole 10-year period to meet the minimum data requirements, the package will still run the formulas and provide statistical summary output using the months available from that 10-year period, for informational purposes. However, the station will be flagged as not meeting assessment requirements.

2. <u>Compute confidence intervals and exceedance frequencies</u>

The assessment packages run the following calculations on all stations that have any monthly data, regardless of whether they have enough data to meet the minimum data requirements for assessment

[14] At this stage, biologists may also determine whether any years should be considered "Extreme Weather Years", as described in Chapter 2.5 in WisCALM on *Data Requirements*. If so, and if the biologist feels the extreme weather year resulted in data that would make the assessment result unrepresentative, the biologist may manually check to determine that at least one "normal year" was included in the assessment before making impairment decisions. Gaps in assessment datasets left when samples are determined to be unrepresentative should be filled by either collecting additional data or considering data from outside the standard period of record.

purposes. However, stations that do not meet the minimum data requirements for an assessment are flagged. Years that did not have at least 2 monthly means are also flagged.

Along with the automated assessment packages, an Excel spreadsheet template is also available for performing the calculations described below manually. Manual calculations of the statistical values may be required to assess data that is not in the SWIMS database.

Calculate the grand mean and related statistics
Take the average of monthly means across years to calculate each station's grand mean. Use monthly means from the 'appropriate year range' as described above. The grand mean is used for TP REC & AL, and CHL AL (not for CHL REC). The list of statistical values needed for this calculation and other values useful for assessment and reporting are:

- Applicable impairment thresholds for the lake type
- Grand Mean
- Min
- Max
- 90% CI –Lower (see formula below)
- 90% CI –Upper (see formula below)
- Standard Deviation
- # of data points used
- Period of Record (the most recent 10-year period, starting with the most recent **even numbered** year)
- Year range used from within the period of record
- Number of years used
- Number of monthly means used

Calculate confidence intervals for TP REC & AL, & Chlorophyll AL
The following statistical method applies to the Lakes TP package for both AL and REC. For the Lakes chlorophyll-*a* package, it applies for the AL impairment assessment, but not REC.

The confidence interval (CI) around the mean is:

$$CI = exp\left(\bar{Y} \pm t_{1-\frac{\alpha}{2},N-1}\frac{S}{\sqrt{N}}\right)$$

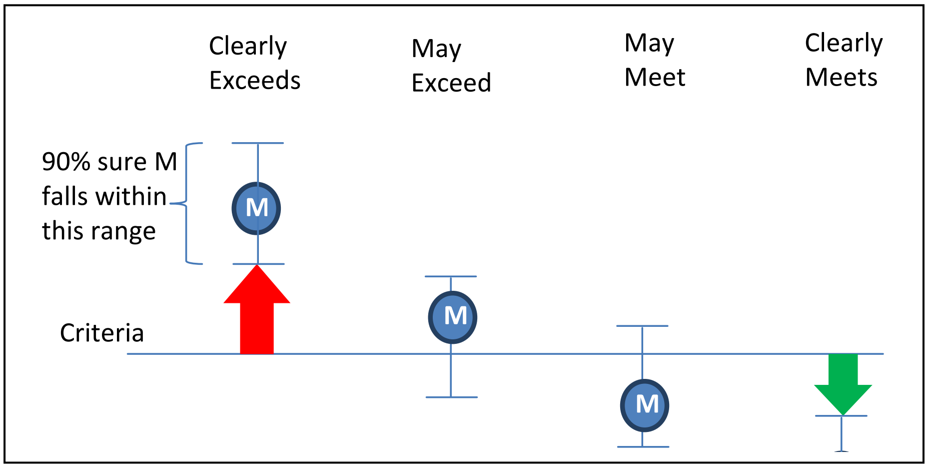
where $\bar{Y}$ and S are the mean and standard deviation, respectively, of the natural logarithms of the measured values, N is the sample size, α is the desired significance level, and $t_{1-\alpha/2,\, N-1}$ is the 100(1-α/2) percentile of the t distribution with N – 1 degrees of freedom.

3. <u>Compare formula results to the applicable criteria/thresholds</u>
For each of the formula runs above (TP REC & AL, and CHLOROPHYLL AL), as well as the CHLOROPHYLL REC described in the next chapter, compare the resulting Upper and Lower 90% Confidence Intervals to the applicable TP criteria and CHLOROPHYLL thresholds for the lake type. The impairment criteria/thresholds for AL are shown in Table 10 on page 31 for AL and in Table 11 on page 44 for REC.

- If Lower 90% CI > criteria = the lake "Clearly Exceeds" the criteria.
- If Upper 90% CI < criteria = the lake "Clearly Meets" the criteria.
- If Grand Mean > criteria, AND lower CI < criteria, AND Upper CI > criteria = the lake "May Exceed" the criteria.
- If Grand Mean < criteria, AND lower CI < criteria, AND Upper CI > criteria = the lake "May Meet" the criteria.

Regardless of whether the decision was a "Clear" decision, the package will report the decision based upon the data points used to meet the minimum data requirements, rather than including older data that may be less representative[15].

Figure 13. Comparison of the Upper and Lower 90% CI and Mean/Median (M) to the criteria.



4. <u>Indicate whether the package results meet the assessment requirements</u>

For TP results, indicate the following:

- Did the data meet the minimum data requirements for assessments? (Need at least 6 monthly means, from at least 2 qualifying years.)

For Chlorophyll results (both REC & AL), indicate the following:

- Do the results qualify for an assessment based on TP and chlorophyll? (Need at least 3 monthly means, from at least 1 qualifying year.)
- Do the results qualify for a "biology-only" assessment? (Need at least 6 monthly means from at least 2 qualifying years).

5. <u>Determine listing categories: Hierarchy of Indicators</u>

Once it has been determined that one or more metrics (TP and/or biological metrics such as chlorophyll or macrophytes) have exceeded an impairment threshold, the department looks at the results of both the TP and biological response indicators in combination to determine which listing category the lake should be placed into. There are several assessment paths that can lead to listing a lake as impaired for TP, chlorophyll-*a*, or a combination of both.

- *TP Only—based on "Overwhelming TP exceedance":* If a lake's lower 90% confidence interval exceeds its phosphorus criterion by 1.5 times[16], it is considered to have an 'overwhelming exceedance' of the phosphorus criteria, and the lake can be listed as impaired based on phosphorus alone, in Category 5A. In this case, only one year of overwhelming exceedance is required if that year is not an extreme weather year (see Chapter 2.5 on page 7 on *Data Requirements* for a definition of extreme weather year), and biological confirmation is not required (though can be included if available).

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[15] The Integrated Reporting workgroup discussed whether to include more data from earlier years to try to reach a more "Clear" decision, but decided against this. If the lake is trending better or worse over time, it is most appropriate to use the most recent data and recommend future monitoring to reach a more "Clear" decision rather than using older data. However, biologists may incorporate less recent data, as appropriate.

[16] For lakes an "overwhelming exceedance" is defined as 1.5 times the phosphorus criteria; for rivers/streams, an "overwhelming exceedance" is defined as 2 times the phosphorus criteria.

- *Biology Only—based on impairment of uses:* If a lake's phosphorus concentration does not exceed the criteria, but at least one biological metric is exhibiting impairment over two years, the lake can be listed for biology only. In these cases, the lake would be listed as having an impaired Aquatic Life or Recreation Use under Category 5A, but the pollutant associated with this impairment may be listed as "Unknown" instead of as "Phosphorus". If it is believed that phosphorus is the causal factor in the biological impairment, the lake may be a good candidate for a more stringent site-specific phosphorus criterion.
- *TP & biology in combination—based on TP and chlorophyll exceedance:* If TP exceeds the criteria but not by 1.5 times, biological confirmation will be used to determine what listing category is appropriate.
    - If at least one of the biological response metrics is poor for at least one year, the lake should be listed as impaired for Aquatic Life and/or Recreation uses under Category 5A, with phosphorus listed as the pollutant.
    - If either insufficient biological data are available to conduct an assessment or biological data are available and do not indicate an impairment, the lake will be placed in Category 5P[17]. This category is a special category on the impaired waters list for waters exceeding TP criteria but without biological information indicating an impairment. More monitoring is needed, and/or other metrics may need to be considered. Category 5P lakes may be good candidates for site-specific phosphorus criteria.

Assessment scenarios incorporating TP and biological data are listed in Table 8. Lake specific listing decisions based on ambiguous TP results are listed in Table 9.

Table 8. Assessing phosphorus and biology in combination to determine impairment status and pollutant.

	Biological Response Indicators	**Overall Assessment Result & EPA Listing Category**	**Pollutant**
Meets TP criteria	None indicate impairment	Not Impaired Category 2	NA
	One or more indicate impairment	Impaired – Biology Only Category 5A	Unknown
Exceeds TP criteria (not an overwhelming exceedance)	One or more indicate impairment	Impaired – TP & Biology Category 5A	TP
	None indicate impairment	Impaired – Exceeds TP but has insufficient or conflicting biological data Category 5P	TP
Exceeds TP criteria by an overwhelming amount	None needed	Impaired – TP Only (i.e. Overwhelming exceedance) Category 5A	TP

[17] All Category 5P waters require TMDLs, but will be given a low priority for TMDL development.

Table 9. Lake assessment decisions based on ambiguous phosphorus results and associated chlorophyll-*a* results. Chlorophyll-*a* results can be assessed without TP if there are 6 samples, meeting minimum data requirements. A listing decision will be made after more monitoring and at least 3 years of data are available.

TP	Chl-*a* (3 or 6 samples)	Assessment Decision	Category Decision
May Meet	Clearly Exceeds (3)	Not Impaired – Monitoring Priority	Category 3
	May Exceed (3 or 6)		
	Clearly Meets (3)	Not Impaired – Monitoring Recommended	
	May Meet (3 or 6)		
	Clearly Meets (6)	Not Impaired	Category 2
May Exceed	Clearly Exceeds (3)	Not Impaired – Monitoring Priority	Category 3
	May Exceed (3 or 6)		
	May Meet (3 or 6)		
	Clearly Meets (3)		
	Clearly Meets (6)		Category 2

Delisting Total Phosphorus

Because the TP assessment method involves the comparison of confidence interval ranges to the applicable thresholds, the calculated value that is compared against the water quality standard is different for listing versus delisting. The *lower* 90% confidence limit value is compared against the applicable criterion for listing decisions and the *upper* 90% confidence limit value is compared against the applicable criterion for delisting decisions. This method increases confidence in listing and delisting decisions and, for waters with ambient concentrations that hover around the applicable criterion, reduces the potential variability in attainment status and to avoid multiple changes to listing status for the same water due to natural variability in TP concentrations.

Dissolved Oxygen (DO)

Low DO in lakes occurs when oxygen consuming processes such as microbial respiration of organic matter exceed oxygen producing processes, such as aeration and photosynthesis. A lake is impaired for DO when the primary cause of low DO is related to human influence, such as eutrophication or discharge of materials that exert biochemical oxygen demand (BOD).

Data Requirements

a) *Period of record.* Data from the most recent 10-year period may be used, but data from the most recent 5 years is given preference, as it is more representative of current conditions.

b) *Seasonal Range and Frequency.* A minimum of 10 discrete values, measured on separate calendar days during the ice-free period.

c) *Measurement Depth.* DO should be measured in the epilimnion[18] of a lake, either at a discrete depth or over a vertical profile. With vertical profiles, the minimum DO in the epilimnion is used in calculations.

[18] Two-Story Lake measurements should be taken where coldwater fish species are found, which may include the metalimnion. Updated assessment protocols for Two-Story lakes have been drafted and will be added once DO criteria are updated in Wisconsin Administrative Code.

d) *Units.* DO values should be expressed in mg/L.

e) *Data Quality*. Data should only be used from DO meters where calibration records are available, or from titration methods.

Calculations and Exceedance Frequencies

a) *Calculations.* Calculate the percentage of all DO values that meet the data requirements described above.

b) *Exceedance Frequency.* If more than 10% of the qualifying DO values are less than 5 mg/L, the lake is impaired for DO.

Macrophytes (aquatic plant metrics)

Aquatic plants respond to human disturbance (Lacoul & Freedman 2006, Wilcox 1995). Certain plant species are lost when nearshore areas are developed or when non-point source pollution, especially phosphorus, impacts water chemistry, triggering a response from aquatic plant communities. Plants can be used as a metric to signify ecological impairment, for example, due to eutrophication. The department has employed a standardized point-intercept sampling method beginning in 2005 to make data more comparable across lakes and to gain lake-wide coverage of the entire aquatic plant community (Hauxwell et al. 2010, Mikulyuk et al. 2010). Methodological standardization has resulted in high among-lake comparability and robust estimations of species richness and frequency of occurrence.

Multivariate community analysis can be used to compare aquatic plant communities in assessment lakes to those in undisturbed reference sites. Lakes that have substantially different plant communities from reference lakes can be flagged for further investigation. The aquatic plant data from flagged systems can then be used to calculate a number of metrics that indicate human perturbation. Individual metrics can be combined into a comprehensive index score. One of these indices, called the Aquatic Macrophyte Community Index, or AMCI, decreases with increasing human disturbance. This multi-metric aquatic plant index was created by Nichols, Weber, and Shaw (2000) using data from transect-based plant surveys of Wisconsin lakes. Current analysis is underway to evaluate the component metrics of the AMCI and consider additional or alternative plant metrics that are most informative at identifying impaired lakes.

Because a waterbody's overall AMCI score reflects a wide range of stressors, WDNR researchers have determined that for purposes of impairment [303(d)] listing related to individual stressors such as phosphorus, it is more appropriate to use a combination of plant community information and individual plant metrics correlated to that stressor, instead of the overall AMCI score. WDNR has developed protocols for assessing the following variables and metrics that correlate to elevated phosphorus levels and eutrophication impairments in Wisconsin lakes:

- Plant species abundance
- Plant community composition
- Relative % littoral area vegetated
- Relative % tolerant species
- Maximum depth of plant growth

Biological impairment will be analyzed using a reference condition approach. We selected a pool of reference lakes representing regional least-impacted conditions as defined by land-use at the watershed and local scale (100m shoreline buffer). The reference plant communities serve as benchmarks against which other plant communities may be compared. However, environmental factors not related to humans influence aquatic plant communities and also must be accounted for before making comparisons

(Mikulyuk et al. 2011). Thus, we grouped reference lakes according to plant community composition. Lakes fell into three major groups that were best explained by latitude and substrate type (soft vs. sandy). The assessment procedure involves assigning category membership to new assessment lakes (based on latitude and substrate), and then comparing the test community to those communities in the appropriate reference group using multivariate methods (Reynoldson et al. 1995). If plant communities in comparison lakes are found to be significantly different, then an investigation into the possible sources of impairment proceeds first by evaluating the scores of individual impairment metrics.

The impairment indicated by different aspects of an aquatic plant community will vary. For example, maximum depth of plant growth (MDC) and relative frequency of tolerant species (TOL) both indicate an eutrophication impairment, while frequency of floating-leaf plants (FLOAT) signifies a habitat degradation impairment. The metrics that appear to be most strongly related to land-use disturbance are frequency of floating-leaf plants (buffer zone urban disturbance) and relative frequency of tolerant species (watershed agriculture disturbance).

An aquatic botanist review team will review plant metrics and make a determination based on their established protocols and best professional judgment as to whether Aquatic Life uses are impaired due to aquatic plants. Such a determination may also be used to corroborate total phosphorus exceedance.

Chloride

Chloride is a concern for Wisconsin waters in part because of road salt used in the winter months. In surface waters chloride can be toxic to many forms of aquatic life. The chloride standards are set to protect aquatic life from chronic (long-term) and acute (short-term) toxicity. The criterion for chronic toxicity is 395 mg/L and for acute toxicity it is 757 mg/L. These criteria apply to AL use of streams, rivers, lakes, reservoirs, and impoundments. Chloride levels may be assessed at any time during the year because the aquatic community may be detrimentally impacted regardless of season; however, levels tend to be highest after snow melts.

For lakes, reservoirs, and impoundments samples can come from any depth and are not averaged across depths if a profile is taken. The highest chloride value at any depth is considered the daily maximum. A waterbody is considered impaired for chronic toxicity if a 4-day average of the daily maximum values taken from 4 consecutive days exceeds the chronic criterion more than once in a three-year period[19]. For acute toxicity, a waterbody is considered impaired if the daily maximum exceeds the acute criterion more than once in a three-year period (Table 5). Chloride has been assessed on a systematic statewide basis since the 2014 assessment cycle.

[19] A chronic value determination for a water can be made if a single data point is available over a 4-day period. To assess whether the chronic criterion is being attained, 2 values would need to exceed the chronic criterion within a 3-year period, as identified in table 15.

Table 10. Aquatic Life Use impairment thresholds for lake natural communities.

Indicators	Min. Data Requirement[4]	Exceedance Frequency (see text for details)	Impairment Threshold – LAKES – Aquatic Life Use						
			Shallow			Deep			
			Headwater Drainage Lake	Lowland Drainage Lake	Seepage Lake	Headwater Drainage Lake	Lowland Drainage Lake	Seepage Lake	Two-story fishery lake
Biological indicators									
Chlorophyll-*a*	3 monthly values from each of two years[3] from the period July 15 – Sept. 15	Lower bound 90%CI of the mean exceeds threshold	≥27 µg/L[6] (≥63 TSI)			≥27 µg/L (≥63 TSI)			≥10 µg/L (≥53 TSI)
Aquatic plant metrics	*Baseline aquatic plant survey*	*NA (1 survey)*	*(Data will be reviewed by DNR's Aquatic Botanist Review Team for impairment assessments)*						
Conventional physical-chemical indicators									
Total phosphorus (TP)	3 monthly values from the period June 1 –Sept. 15	Lower bound 90%CI of the mean exceeds threshold	≥40 µg/L[7]			≥30 µg/L[7]		≥20 µg/L[7]	≥15 µg/L
Dissolved oxygen (DO)	10 discrete[1] epilimnetic values (ice free period, epilimnetic samples)	Greater than 10% of values	< 5 mg/L						< 5 mg/L[8]
Temperature	20 discrete[1] values collected within a given calendar month	Greater than 10% of daily maximum or any weekly average temperature values[5] in a calendar month	See Table 4 of NR 102.25(4) of Wis. Admin. Code for acute and sub-lethal temperature criteria by calendar month for non-specific waters						
pH	10 discrete[1] values	Vary (see thresholds)	- Outside the range of 6.0-9.0 - Change >0.5 units outside natural seasonal maximum (mean) & minimum (mean) [2]						
Aquatic Toxicity-based indicators									
Acute aquatic toxicity	2 values within a 3-year period	Maximum daily concentration not exceeded more than once every 3 years	Criteria in NR 105.05 Wis. Adm. Code						
Chronic aquatic toxicity		Maximum 4-day concentration not exceeded more than once every 3 years	Criteria in NR 105.06 Wis. Adm. Code						

(1) Discrete values refer to samples collected on separate calendar days. DO, temperature, and pH criteria are taken from s. NR 102.04, Wis. Adm. Code, Water Quality Standards for Wisconsin Surface Waters.
(2) Based on historical data or reference site.
(3) When used in combination with TP criteria exceedance to assess impairment, chlorophyll data from only one year is required.
(4) Smaller datasets may be considered in certain cases, such as a high magnitude of exceedance.
(5) Weekly average temperature values are calculated using the daily max values when comparing data against applicable sub-lethal criterion.
(6) The chlorophyll-*a* threshold in shallow lakes changed from 60 µg/L (used from 2012 – 2016) to 27 µg/L. The new criterion of 27 µg/L represents expected chlorophyll-*a* values at lakes that have a tropic status at the high end of eutrophic but that have not yet become hyper-eutrophic (Trophic State Index (TSI) of 63, Figure 12). At this stage, the lake still may be restored to a clear water state.
(7) Lake total phosphorus thresholds for Aquatic Life use were changed to match the thresholds for Recreation use. These are the thresholds codified in Chapter NR 102 of Wis. Admin. Code.
(8) Minimum data requirements and assessment methods slightly different for Two-Story Fishery lakes. Refer to pages 28 – 29 for details.

4.6 Lake Impairment Condition Assessment: Recreation Use

Recreation Use impairments for lakes are based primarily on both phosphorus and chlorophyll-*a* (Chlorophyll-*a*) levels, as Chlorophyll-*a* is a measure of algal concentrations. The protocols for assessing both phosphorus and chlorophyll were revised significantly in 2014 from those used in 2012. The assessments now utilize a more sophisticated statistical approach that more appropriately accounts for the variability of water quality samples. As with Aquatic Life listings, once individual metrics for eutrophication are assessed, phosphorus results should be reviewed in combination with biological response indicators such as chlorophyll to make a determination as to which listing category the lake should be placed into. This is described in Chapter 4.5 Lakes Aquatic Life, under the subheading "Determine listing categories".

Total Phosphorus (TP)
For Recreation uses, TP data are assessed in the same way as described in Chapter 4.5 Lake Impairment Condition Assessment: Aquatic Life (AL) Use.

Algal blooms (chlorophyll-*a*)
Algae, including blue-green algae, are naturally occurring organisms found throughout the state and are an important part of Wisconsin's freshwater ecosystem. However, excessive nutrient loading (particularly phosphorus) can cause algae populations to grow rapidly under certain environmental conditions and form "blooms" that can impact water quality and pose health risks to people, pets, and livestock. Blue-green algae pose the greatest nuisance and risk to those recreating. Most blue-green algae are buoyant and when populations reach bloom densities, they float to the surface where they form scum layers or floating mats. In Wisconsin, blue-green algae blooms generally occur between mid-June and late September, although in rare instances, blooms have been observed in winter, even under the ice.

Algae blooms can cause many water quality problems including: a) reduced light penetration affecting the ability of macrophytes to thrive; b) discoloration of water; c) taste and odor concerns, and d) reduced DO concentrations due to massive decomposition of the cells when they die-off. Another important consequence of blue-green algae is their ability to produce naturally-occurring toxins. Effects of algal toxicity and related thresholds are discussed further in the Public Health and Welfare Uses Chapter.

Calculating percent days with moderate algal levels[20] *and confidence intervals for* Chlorophyll-*a*
The assessment protocol for determining if Chlorophyll-*a* is exceeding a Recreation use threshold is significantly different from that used prior to the 2014 assessment cycle. Initially, the threshold was a concentration threshold, similar to that used for TP. The protocol was changed in 2014 to better reflect actual impairments of Recreation uses, and to better capture the variability of chlorophyll in lakes. The protocol now uses the <u>percent of days</u> during the sampling season that a lake experiences <u>moderate algal levels</u> as its benchmark for assessments. Moderate algal levels are defined as exceeding 20 µg/L chlorophyll-*a*. This was defined based on user perception surveys conducted in Minnesota. For deep lakes, the impairment threshold is 5% of days of moderate algal levels during the sampling season. For

[20] The term "moderate algae level" is replacing the term "nuisance algal bloom" that was used in the 2018 WisCALM guidance. Through discussions with stakeholders, it became apparent that "nuisance algal bloom" led people to envision worse conditions than are actually present at 20 µg/L chlorophyll-*a*. Based on Wisconsin lake user perception surveys, at 20 µg/L, half of lake users perceive some impairment to their enjoyment and recreation due to algae, but over 90% would still swim. It was determined that "moderate algae level" better described this condition. As algae levels rise higher than 20 µg/L chl-*a*, the number of lake users that would swim decreases rapidly.

shallow lakes, the impairment threshold is 25% of days of moderate algal levels during the sampling season.

For Chlorophyll-*a* Recreation use assessments, the same protocols apply for data selection and calculating a grand mean as those described in Chapter 4.5 Lake Impairment Condition Assessment: Aquatic Life (AL) Use. However, the following statistical formula replaces that found under the sub header "Calculate confidence intervals for TP REC & AL, & Chlorophyll AL."

The statistical formula for Chlorophyll-*a* Recreation assessments determines the frequency that a lake exceeds a specific chlorophyll threshold, and also calculates the 90% confidence interval. This formula is difficult to run manually but can be done through use of a programming package such as "R" (http://www.r-project.org/). Use the following procedure to calculate the percent of days a lake is exceeding 20 µg/L chlorophyll-*a* (P):

1. Using the chlorophyll sample values, calculate $= \frac{20-\bar{x}}{\sigma}$, where $\bar{x}$ is the sample mean and σ is the sample standard deviation.
2. Using the T table provided by the department[21], for each confidence level (lower 90%, Tlow; median, Tmed; and upper 90%, Thigh), and for the appropriate value of n (number of samples), find the value of T that is closest to the one calculated in step 1.
3. Report the value of P that is associated with the value of T that was selected in step 2.

In the absence of meeting minimum data requirements (for instance, nearshore data are available but not from the deep station), the professional judgment of the District Biologist should be used to consider listing any waterbody that experiences frequent and severe algal blooms where there is strong reason to believe that designated uses are impaired and nutrient levels may be contributing to such blooms. Information such as taste and odor complaints, documentation of toxin-producing blue-green algae genera, and algal cell counts can be used as justification for impairment determinations based on best professional judgment.

[21] The department can provide the appropriate T table file upon request as a CSV file (Ttable.csv).

Table 11. Recreation impairment thresholds for lake natural communities.

Note: For all parameters, the assessment period is the most recent 10-year period. For TP and chlorophyll-*a*, data from within the most recent 5-year period are prioritized for impairment assessments.

Indicators	Min. Data Requirement (see text for details)	Exceedance Frequency (see text for details)	Impairment Threshold – LAKES – Recreation Use						
			Shallow			Deep			
			Headwater Drainage Lake	Lowland Drainage Lake	Seepage Lake	Headwater Drainage Lake	Lowland Drainage Lake	Seepage Lake	Two-story fishery lake
Conventional physical-chemical indicators									
Total phosphorus (TP)	3 monthly values from each of two years from the period June 1 – Sept. 15	Lower bound 90%CI of the mean exceeds threshold	≥40 µg/L			≥30 µg/L		≥20 µg/L	≥15 µg/L
Biological indicators									
Chlorophyll-*a* (1)	3 monthly values from each of two years(2) from the period July 15 – Sept. 15	Lower bound 90%CI of the mean exceeds threshold	> 25% of days in sampling season have moderate algal levels (> 20 µg/L)			> 5% of days in sampling season have moderate algal levels (> 20 µg/L)			
Aquatic plant metrics	Baseline aquatic plant survey	N/A (one survey)	*(reserved until guidance available)*						

(1) While the TP impairment thresholds for the Recreation Use are based on codified criteria, the chlorophyll-*a* thresholds for impairment and plant metrics assessments protocols are not codified.

(2) When used in combination with a TP dataset for impairment assessments, chlorophyll data from only one year is required.

Macrophytes (aquatic plants)

Although healthy aquatic plant communities are necessary for a good quality lake system, impacted lakes that receive high nutrient inputs may respond not with excessive algal blooms (and the associated high chlorophyll-*a* values), but instead may exhibit very high macrophyte growth that is matted and densely topped out across the lake surface. This can impact recreational boating and swimming if it becomes a severe problem.

The department has developed listing protocols based on macrophyte metrics for use in determining Aquatic Life use impairments, as described in Chapter 4.5 Lakes Aquatic Life on page 43. However, more research is needed to define how to appropriately conduct Recreation use assessments based on macrophytes. WDNR recognizes the importance of developing such a protocol and hopes to further investigate this issue through additional research and data review, for use in future listing cycles. Such research may investigate correlations between density of macrophytes or frequency of species occurrence with impacts such as inhibited Recreation uses or increased issuance of Aquatic Plant Management permits.

Invasive species such as Eurasian Water Milfoil and Curly Leaf Pondweed often contribute to high macrophyte levels. However, Wisconsin does not list waters as impaired due to invasive species, as no guidance is yet available from EPA on how to do so.

Inland and Great Lakes Beaches

Many, but not all, beaches are evaluated for Recreation Uses in Wisconsin. Federal criteria for *Escherichia coli* (*E. coli*) are applicable to the open waters of the Great Lakes – including beaches. In Wisconsin, inland beaches follow the same monitoring and assessment protocol as the Great Lakes beaches. *E. coli* is a species of bacteria that serves as an indicator of the presence of fecal matter in the water – suggesting that there may be harmful bacteria, viruses, or protozoans present that elevate risk to humans.

Monitoring for *E. coli* at many public beaches along the shorelines of Lake Michigan and Lake Superior is conducted in accordance with the Beach Environmental Assessment and Coastal Health Act of 2000 (the BEACH Act). As of the 2015 beach season, approximately 100 monitoring sites[22] at public beaches in Wisconsin are sampled for *E. coli* for implementation of the BEACH Act. Beaches included in the monitoring program get sampled between 1 and 4 times per week depending on the tier or priority given to the beach and local resources. Established monitoring frequency considers beach usage, historic water quality or impairment status, potential contaminant sources, and available resources. For more information on Wisconsin's Beach Program please visit: http://dnr.wi.gov/topic/beaches/ and www.wibeaches.us.

Although *E. coli* may not be representative of the pathogen strains that result in illness to humans, its presence suggests that fecal matter may be in the water and that other pathogens may be present. It is often these and other pathogens that result in water borne illnesses in humans. Data from this effort are used to make decisions on which beaches are impaired – namely due to chronic closure problems due to the presence of high counts of *E. coli* bacteria.

EPA has established two different water quality criteria for *E. coli* – a single sample maximum of 235 colony forming units (cfu) /100 mL and a long-term geometric mean[23] maximum of 126 cfu/100 mL. Beach closure decisions are routinely made considering the single sample maximum value. However, when evaluating *E. coli* data to determine if a beach should be included on the Impaired Waters List, WDNR relies on long-term data sets.

To assess the attainment of Recreation uses at Wisconsin beaches, WDNR aggregates by month all data collected from beaches during the "beach season" (defined as May 1 through September 30) over the past five years[24]. The data is aggregated by month because it more closely approximates the "five samples per month" requirement of the geometric mean criterion and recognizes that typical sampling frequencies are often less than five times per month. For example, Monthly aggregate data sets with fewer than five data points are considered insufficient for assessing Recreation use support. If one or more of the monthly-aggregated geometric means exceeds the criterion of 126 cfu/100 ml, the beach will be identified as not supporting its recreation use and placed on the Impaired Waters List. When a beach is included on the proposed Impaired Waters List, the pollutant is listed as *E. coli* and the impairment is identified as "Recreational Restrictions – Pathogens." WDNR will propose to remove a beach from the Impaired Waters List when the monthly-aggregated geometric means of data collected during the previous five years meet the criterion of 126 cfu/100 ml. WDNR believes this is an appropriate way of recognizing chronic risk to human health associated with recreational activities in water with long-term elevated levels of *E. coli.*

Delisting a beach

For delisting a beach new E. coli data used in the calculation need to show that no monthly-aggregated geometric mean exceeds the criterion of 126 cfu/100 ml. Even if a beach shows no exceedance of the 126 cfu/100 ml local biologists and project managers can consider the frequency of beach closures and other factors in whether the beach should be delisted.

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[22] A few large beaches require multiple sites to reflect condition. In these cases, samples from multiple sites on one beach are often combined to make up a composite sample.

[23] A geometric mean is a measure of central tendency calculated by multiplying a series of numbers and taking the n^{th} root of the product, where *n* is the number of items in the series

[24] For example, a five year lake assessment period for the 2018 Impaired Waters List is January 1, 2012 through December 31, 2016.

4.7 Lake Impairment Condition Assessment: Public Health and Welfare Uses

Harmful Algal Blooms- Blue-green Algal Toxin Health Risks

Algal toxins can be harmful to humans and animals alike through skin contact, inhalation, or ingestion. Some of the species commonly found in Wisconsin that produce algal toxins include *Anabaena* spp., *Aphanizomenon* spp., *Cylindrospermopsis raciborskii*, *Dolichospermum* spp., *Microcystis* spp., and *Planktothrix* spp. Illnesses related to blue-green algae can occur in both humans and animals. People may be exposed to these toxins through contact with the skin (e.g., when swimming), through inhalation (e.g., when motor boating or water skiing), or by swallowing algal cells or toxins in water. Where monitoring of blue-green algae occurs, notices are provided to local public health agencies when concentrations are presumed to exceed 100,000 cells/mL. The World Health Organization (WHO) reports exceeding a density of 100,000 cyanobacterial cells per ml (which is equivalent to approximately 50 µg/L of chlorophyll-*a*, if cyanobacteria dominate) as a guideline for a high illness risk in recreational waters (WHO 2003). At this density, 20 µg/L of microcystins are likely. This toxin concentration is equivalent to 20 times the WHO provisional guideline value for microcystin-LR in drinking water, but would result in consumption of an amount close to the tolerable daily intake for an adult of 60 kg consuming 100 ml of water while swimming (rather than 2 liters of drinking water) (

Table 12).

Table 12. World Health Organization indicator thresholds of high health risk associated with potential exposure to cyanotoxins.

Indicator (units)	Thresholds
Chlorophyll-*a* (µg/L)	≥50
Cyanobacteria cell counts (cells/mL)	≥ 100,000
Microcystin (µg/L)	>20

Best professional judgment will be used to determine whether a waterbody exceeds the thresholds in

Table 12 at a frequency that prevents attainment of the Public Health and Welfare use. When a waterbody is proposed to be included on the impaired waters list due to frequent and elevated blue-green algal cell counts or toxins, the impairment indicator in the WATERS database should be identified as "Recreational Restrictions – Blue-green Algae." If the cause of impairment can be identified (e.g., total phosphorus concentrations), then the pollutant should also be listed. In the absence of meeting minimum data requirements to assess pollutant data (for instance, nearshore TP data is available but not deep station data), professional judgment should be used to consider listing any waterbody that experiences frequent and severe blue-green algal blooms or elevated levels of toxins where there is strong reason to believe that nutrient levels may be contributing to such blooms.

4.8 Lake Impairment Condition Assessment: Wildlife Use

Wildlife criteria protect wildlife that consume surface water and aquatic organisms. Table 13 shows the wildlife criteria in NR 105.07(1), Wis. Adm. Code.

Table 13. Wildlife Criteria from NR105.07.

Substance	Criteria (ng/L, except where indicated)	Minimum Data Requirement	Exceedance Frequency
DDT & Metabolites	0.011	2 values within a 3-year period	Criteria not exceeded more than once every 3 years
Mercury	1.3		
PCBs	0.12		
2,3,7,8 – TCDD	0.003 (pg/L)		

5.0 Stream & River Classification and Assessment Methods

5.1 Stream and River Classifications

The condition of streams and rivers in Wisconsin are currently assessed for the following use designations: Aquatic Life, Recreation Use, Public Health and Welfare (Fish Consumption) and General Uses. The following provides details on the classifications and water quality goals against which waters are assessed.

Aquatic Life: Stream and River Classifications

Assignment of designated uses for the protection of fish and aquatic life has been an iterative process dating back to the late 1960's. Many of the designated uses that are included in the Wis. Adm. Code date back to the 1980's. While efforts are underway to revise AL use subcategories, the current codified AL use designation subcategories in ch. NR 102, Wis. Adm. Code will be used for evaluating WQS attainment status. as defined in s. NR 102.04(3), Wis. Adm. Code, Wisconsin's Aquatic Life (AL) use designations for streams and rivers are categorized into the following subcategories:

- **Coldwater (Cold) Community**: Streams capable of supporting a cold-water sport fishery or serving as a spawning area for salmonids and other cold-water fish species. Representative aquatic life communities associated with these waters generally require cold temperatures and concentrations of DO that remain above 6 mg/L. Since these waters are capable of supporting natural reproduction, a minimum DO concentration of 7 mg/L is required during times of active spawning and support of early life stages of newly-hatched fish.

- **Warmwater Sport Fish (WWSF) Community**: Streams capable of supporting a warm water-dependent sport fishery. Representative aquatic life communities associated with these waters generally require cool or warm temperatures and concentrations of DO that do not drop below 5 mg/L.

- **Warmwater Forage Fish (WWFF) Community**: Streams capable of supporting a warm water-dependent forage fishery. Representative aquatic life communities associated with these waters generally require cool or warm temperatures and concentrations of DO that do not drop below 5 mg/L.

- **Limited Forage Fish (LFF) Community**: Streams capable of supporting small populations of forage fish or tolerant macroinvertebrates that are tolerant of organic pollution. Typically limited due to naturally poor water quality or habitat deficiencies. Representative aquatic life communities associated with these waters generally require warm temperatures and concentrations of DO that remain above 3 mg/L.

- **Limited Aquatic Life (LAL) Community**: Streams capable of supporting macroinvertebrates and/or occasionally fish that can tolerate organic pollution. Typically, this category includes small streams with very low-flow and very limited habitat. Certain marshy ditches, concrete line-drainage channels, and other intermittent streams. Representative aquatic life communities associated with these waters are tolerant of many extreme conditions, and require concentrations of DO that remain above 1 mg/L.

Aquatic Life use designations for individual waters are defined in chs. NR 102 or 104, Wis. Adm. Code. In some cases, coldwater fish communities referenced in the 1980 Trout Book (Wisconsin Trout Streams – Publication 6-3600(80)) may be *codified by reference.* Waters that are not referenced in code are considered *default* AL waters and are assumed to support either a coldwater community or warmwater community depending on water temperature and habitat.

Natural Communities

Streams and rivers are evaluated for placement in a revised Aquatic Life use classification system, in which the Aquatic Life use subclasses are referred to as *Natural Communities*. Natural Communities are defined for streams and rivers using model-predicted flow and temperature ranges associated with specific fish and/or macroinvertebrate communities. This model, developed by the USGS and WDNR Science Services research staff, generated proposed stream natural communities based on a variety of base data layers at various scales. The Natural Communities data layer for Wisconsin rivers and streams identifies which fish index of biological integrity (F-IBI) to apply when assessing our waters. The following Natural Communities have been defined:

Macroinvertebrate – very small, almost always intermittent streams (i.e., cease flow for part of the year, although water may remain in the channel) with a wide range of summer temperatures. No or few fish (< 25 per 100 m of wetted length) are present, but a variety of aquatic invertebrates may be common, at least seasonally.

Coldwater – small to large perennial streams with cold summer water temperatures. Coldwater fish range from common to dominant (25-100% of individuals), transitional fish from absent to abundant (up to 75% of individuals), and warmwater fish from absent to rare (0-5% of individuals). Small-stream, medium-stream, and large-river fish range from absent to dominant (0-100% of individuals).

Cool-Cold Headwater – small, usually perennial streams with cool to cold summer water temperatures. Coldwater fish range from absent to abundant, transitional fish from common to dominant, and warmwater fish from absent to common. Small-stream fish range from very common to dominant (50-100% of individuals), medium-stream fish from absent to very common (0-50% of individuals), and large-river fish from absent to uncommon (0-10% of individuals).

Cool-Cold Mainstem – moderate to large but still wadeable perennial streams with cool to cold summer water temperatures. Coldwater fish range from absent to abundant, transitional fish from common to dominant, and warmwater fish from absent to common. Small-stream fish range from absent to very common, medium-stream fish from very common to dominant, and large-river fish from absent to very common.

Cool-Warm Headwater – small, sometimes intermittent streams with cool to warm summer temperatures. Coldwater fish range from absent to common, transitional fish from common to dominant, and warmwater fish from absent to abundant. Small-stream fish range from very common to dominant, medium-stream fish from absent to very common, and large-river fish from absent to uncommon.

Cool-Warm Mainstem – moderate to large but still wadeable perennial streams with cool to warm summer temperatures. Coldwater fish range from absent to common, transitional fish from common to dominant, and warmwater fish from absent to abundant. Small-stream fish range from absent to very common, medium-stream fish from very common to dominant, and large-river fish from absent to very common.

Warm Headwater – small, usually intermittent streams with warm summer temperatures. Coldwater fish range from absent to rare, transitional fish from absent to common, and warmwater fish from abundant to dominant. Small-stream fish range from very common to dominant, medium-stream fish from absent to very common, and large-river fish from absent to uncommon.

Warm Mainstem – moderate to large but still wadeable perennial streams with warm summer temperatures. Coldwater fish range from absent to rare, transitional fish from absent to common, and warmwater fish from abundant to dominant. Small-stream fish range from absent to very common, medium-stream fish from very common to dominant, and large-river fish from absent to very common.

Large Rivers – non-wadeable large to very-large rivers. Summer water temperatures are almost always cool-warm or warm, although reaches are identified based strictly on flow. Coldwater fish range from absent to rare, transitional fish from absent to common, and warmwater fish from abundant to dominant. Small-stream fish range from absent to uncommon, medium-stream fish from absent to common, and large-river fish from abundant to dominant.

Relatively few of the modeled stream segments have data on flow, water temperature, or fish communities. Thus, segments are initially classified into Natural Communities based on landscape-scale statistical models that predict long-term flows and temperatures from watershed characteristics such as watershed size, surficial and bedrock geology, topography, climate, and land cover. These predictions represent the realistic potential Natural Community of the segment under current land-cover and climate conditions in the absence of significant site-specific human impacts, such as local riparian degradation. The Natural Community model is occasionally updated, and the most current model is used to classify streams that do not have monitored data.

In independent validation tests, the models were found to be largely unbiased and to predict the correct Natural Community for about 70-75% of test segments. However, for some test segments the predicted Natural Community was different from the Natural Community that actually occurred. Errors in Natural Community classification will reduce the accuracy of bioassessment. Misclassified streams will be assessed with the wrong IBI, and their environmental condition may be misjudged. Misclassified segments can only be detected through collection of appropriate field data. A separate guidance document (Lyons, 2013) was developed to provide guidelines on validating or correcting a modeled Natural Community Classification, including the types of data that should be collected, how the data should be interpreted, and how new classifications should be determined. This guidance document is included in Appendix D.

5.2 Selecting Representative Stations

Station Locations: Selecting representative stations for assessment

Station selection is determined by the regional DNR biologist. In general, most river and stream stations are used for water quality assessments, so long as they are representative of the river or stream segment as a whole. Biologists can change which stations are selected by the package by using the checkbox in WATERS under "Use for Assessment Pkgs?" (Figure 14).

The following are reasons a river or stream site may not be representative. Station is:

- Near a discharger outfall;
- Within a half mile of lake or reservoir outlet;
- Not an appropriate station type (Beach, Boat Launch, Facility).

Station selection is based on best professional judgment of the biologists; more information on professional judgment is available in section 7.2 Professional Judgment.

Stations

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	Station ID	Station Name	Water Body	WBIC	Use for Assessment Pkgs?
	10033682	Yahara River at South St. Bridge	Yahara River	798300	☑
	10033681	Yahara River at Veteran's Park	Yahara River	798300	☑
	10033680	Yahara River at Acker	Yahara River	798300	☑
	10031648	Yahara River at River Park Rd	Yahara River	798300	☑
	10031647	Yahara River at Stewald Property S of cul de sac ~300ft	Yahara River	798300	☑
	10029796	Yahara River at the western part of Green Park in DeForest	Yahara River	798300	☑
	10012035	Yahara River Upstream River Rd. 2nd Crossing	Yahara River	798300	☑
	10012033	Yahara River -Upstream Of River Road 1st Crossing	Yahara River	798300	☑

Figure 14. Station selection in WATERS for a river or stream segment. WATERS access is available to DNR staff only.

5.3 Stream and River General Condition Assessment

Aquatic Life General Assessments

WDNR uses biological indices, including fish indices of biological integrity (F-IBI) and the macroinvertebrate index of biological integrity (M-IBI), to determine whether current water quality conditions support the Aquatic Life designated use.

Fish Indices of Biological Integrity

Multiple, peer-reviewed F-IBIs have been developed by WDNR research staff and are used to assess the biological health and quality of fish assemblages of streams and rivers (Lyons, Wang, and Simonson 1996; Lyons 1992, 2001, 2006, and 2012). F-IBIs have been customized to account for differences in stream morphology, water temperature and fish species associated with rivers and streams. The IBIs "…explicitly formulate an expected condition for the biota in the absence of substantial environmental degradation and take into account inherent natural sources of variation in community characteristics. Based on empirical data, the relationship between the biological community and the amount of environmental degradation is estimated" (Lyons et al., 2001). An objective procedure was used to select and score the metrics that compose the various F-IBIs, choosing metrics that represent a variety of the structural, compositional, and functional attributes of fish assemblages (Table 12).

Table 14. Fish Indices of Biological Integrity for Wisconsin streams and rivers.

	Cold F-IBI (Lyons et al., 1996)	**Warm F-IBI** (Lyons, 1992)	**Small F-IBI** (Lyons, 2006)	**Large River F-IBI** (Lyons et al., 2001)	**Cool-Warm F-IBI** (Lyons, 2012)	**Cool-Cold F-IBI** (Lyons, 2012)
Temperature	Maximum daily mean <22° C	Maximum daily mean >22° C	Maximum daily mean >22° C	N/A	Maximum daily mean 22.6–24.6 °C	Maximum daily mean 20.7–22.5 °C
Applicable Stream Size & Location	Streams of any size or watershed area	Wadeable streams of a width between 2.5m and 50m, and depth of at least ~1.25m	Streams with watershed areas that are $4km^2$ to $41km^2$	Rivers with at least 3km of contiguous, non-wadeable channel	Scoring criteria depend on the watershed area (“large” is > 200 km^2 and “small” is ≤ 200 km^2) and latitude (“north” > 44.6◦N and “south” is ≤ 44.6◦N)	Scoring criteria depend on the watershed area (“large” is > 200 km2 and “small” is ≤ 200 km2) and latitude (“north” > 44.6◦N and “south” is ≤ 44.6◦N)
Individual Metrics	a) # intolerant species b) % tolerant species c) % top carnivore species d) % native or exotic stenothermal coldwater or coolwater species, e) % salmonid individuals that are brook trout	a) # native species b) # darter species c) # sucker species d) # sunfish species e) # intolerant species f) % tolerant species g) Percent omnivores h) % insectivores i) % top carnivores j) % simple Hthophils k) # of individuals per $300m^2$ l) % diseased fish	a) # native species b) # intolerant species c) # minnow species d) # headwater species e) Total catch per 100m, excluding tolerant species f) Catch per 100 m of brook stickleback g) % diseased fish	a) Weight Biomass PUE b) # native species c) # sucker species d) # intolerant species e) # riverine species f) % diseased fish g) % riverine h) % lithophils i) % insectivore j) % round suckers	a) # native minnow species b) # intolerant species c) % tolerants d) # benthic invertivore species e) % omnivores	a) # darter, madtom and sculpin species b) # coolwater species c) # intolerant species d) % tolerant species e) % generalist feeders

Macroinvertebrate Indices of Biological Integrity

Data derived from aquatic macroinvertebrate samples, combined with stream habitat and fish assemblages, provide valuable information on the physical, chemical and biological condition of streams. Most aquatic macroinvertebrates live for one or more years in streams, reflecting various environmental stressors over time. Since the majority of aquatic invertebrates are limited in mobility, they are good indicators of localized conditions, upstream land use impacts and water quality degradation.

WDNR uses the M-IBI developed by Weigel (2003) to assess wadeable streams. The M-IBI is composed of various metrics used to interpret macroinvertebrate sample data. The M-IBI was developed and validated for cold and warm water wadeable streams and cannot be used as an assessment tool for non-wadeable rivers or ephemeral streams. The following metrics are included in the M-IBI:

- Species richness
- Ephemeroptera–Plecoptera– Trichoptera (EPT)
- Mean Pollution Tolerance Value
- Proportion of Depositional Taxa
- Proportion of Diptera (Dipt)
- Proportion of Chironomidae (Chir)
- Proportion of Shredders (Shr)
- Proportion of Scrapers (Scr)
- Proportion of Gatherers (Gath)
- Proportion of Isopoda (Isop)
- Proportion of Amphipoda
- Proportion of Shredders (Shr)

A macroinvertebrate IBI has been developed, validated, and applied to assess nonwadeable rivers (Weigel and Dimick 2011). Hester–Dendy artificial substrates were used to conduct a standardized macroinvertebrate survey at 100 sites on 38 nonwadeable rivers in Wisconsin. Ten metrics that represent macroinvertebrate assemblage structure, composition, and function constitute the IBI:

- Number of Insecta taxa
- Number of EPT taxa
- Proportion of Insecta individuals
- Proportion of gatherer individuals
- Proportion of scraper individuals
- Proportion of individuals from the dominant 3 taxa

- Proportion of intolerant EPT individuals
- Proportion of tolerant Chironomidae individuals
- Mean Pollution Tolerance Value
- Number of unique functional trait niches

Fish and macroinvertebrate data are used to calculate the appropriate F-IBI and M-IBI scores. Biological data collected within the last ten years are assessed. General biological condition assessments require at least one F-IBI value or one M-IBI value, whereas at least two values of a particular index are required for impairment assessments. Due to strong temporal variations in biological assemblage characteristics at degraded sites, more samples and a longer time frame are needed to determine biotic integrity at sites with human impacts than is needed at least-impacted sites (Lyons et al., 2001). Natural Community classifications are used to determine which biological index to apply (Table 15).

Table 15. Modeled water temperature and flow criteria used to predict Natural Communities in healthy Wisconsin streams and fish index of biotic integrity (IBI) for bioassessment associated with each Natural Community.

Natural Community	Maximum Daily Mean Water Temperature (˚F)	Annual 90% Exceedance Flow (ft^3/s)	Index of Biotic Integrity
Macroinvertebrate	Any	0.0 – 0.03	Macroinvertebrate
Coldwater	< 69.3	0.03 – 150	Coldwater Fish
Cool-Cold Headwater	69.3 – 72.5	0.03 – 3.0	Small-Stream (Intermittent) Fish
Cool-Cold Mainstem	69.3 – 72.5	3.0 – 150	Cool-Cold Transition (Coolwater) Fish
Cool-Warm Headwater	72.6 – 76.3	0.03 – 3.0	Small-Stream (Intermittent) Fish
Cool-Warm Mainstem	72.6 – 76.3	3.0 – 150	Cool-Warm Transition (Coolwater) Fish
Warm Headwater	> 76.3	0.03 – 3.0	Small-Stream (Intermittent) Fish
Warm Mainstem	> 76.3	3.0 – 150	Warmwater Fish
Large River	Any	> 150	River Fish

The biological indices respond to watershed scale impacts of agricultural and urban land uses, local riparian stressors, nutrient enrichment, and instream habitat degradation including sedimentation and scouring. In general, as the rate of stream degradation increases, a corresponding decrease in the number of environmentally-sensitive species and an increase in environmentally tolerant species are observed. These changes in aquatic community composition are scored relative to a reference or "least-impacted" condition, and are placed in a condition category based on the resulting score. The condition categories (excellent, good, fair, poor) and corresponding F-IBI scores are shown in Table 16, and the wadeable M-IBI and nonwadeable river M-IBI thresholds are given in Tables 15 and 16, respectively. To determine the biological condition of streams and rivers for assessments, the F-IBI or M-IBI values should be compared against thresholds established for each natural community class.

For general condition assessments, all waters scoring in the excellent, good, or fair categories are considered supporting the AL use, unless corroborating physical or chemical data exceed impairment thresholds. Waters scoring in the poor condition category based on general assessments using one bioassessment result are flagged for follow-up monitoring.

Table 16. Condition category thresholds for applicable fish indices of biotic integrity (IBI).

Natural Community	Fish IBI Type	Fish IBI	Condition Category
Coldwater	Coldwater Fish	81-100	Excellent
		51-80	Good
		21-50	Fair
		0-20	Poor
Cool-Cold or Cool-Warm Headwater	Small-Stream (Intermittent) Fish	91-100	Excellent
		61-90	Good
		31-60	Fair
		0-30	Poor
Cool-Cold Mainstem	Cool-Cold Transition Fish	61-100	Excellent
		41-60	Good
		21-40	Fair
		0-20	Poor
Cool-Warm Mainstem	Cool-Warm Transition Fish	61-100	Excellent
		41-60	Good
		21-40	Fair
		0-20	Poor
Warm Headwater	Small-Stream (Intermittent) Fish	91-100	Excellent
		61-90	Good
		31-60	Fair
		0-30	Poor
Warm Mainstem	Warmwater Fish	66-100	Excellent
		51-65	Good
		31-50	Fair
		0-30	Poor
Large River	River Fish	81-100	Excellent
		61-80	Good
		41-60	Fair
		0-40	Poor

Table 17. Condition category thresholds for wadeable stream macroinvertebrate index of biotic integrity.

Wadeable Stream M-IBI Thresholds	***Condition Category***
> 7.5	Excellent
5.0-7.4	Good
2.5-4.9	Fair
< 2.5	Poor

Table 18. Condition category thresholds for nonwadeable river macroinvertebrate index of biotic integrity.

River M-IBI Thresholds	*Condition Category*
>75	Excellent
50-75	Good
25-49	Fair
<25	Poor

Other Parameters

Any of the parameters assessed to determine stream impairment can also be used for a general condition assessment. Many waters are found to be meeting designated uses through analysis of chemical and/or physical parameters and these waters are considered to be **Fully Attaining** one or more uses. An assessment resulting in attainment, but does not meet the minimum data requirement for a full impairment assessment, is considered **Attaining** one or more uses. An assessment that results in non-attainment, meaning a parameter exceeded criteria, is considered **Not Attaining**. Minimum data requirements for each parameter type and designated use assessment are outlined in the rest of section 5.

5.4 Stream and River Impairment Condition Assessment: Aquatic Life Use[25]

To make an impairment assessment, all available data over the last 10-year period are reviewed.
If a stream or river general assessment category is 'poor', an impairment assessment is conducted. Data up to the past decade, preferably from within the past five years, can be used when conditions are confirmed to be stable throughout the assessment time period. Biological data alone can be used to list a water as impaired, as long as minimum data requirements are met. At least two samples of one biological assemblage (fish or macroinvertebrates) collected in different calendar years are required to assess biological condition for impairment listings. However, if corroborating water quality or physical habitat data exists, one fish survey or one macroinvertebrate sample may be sufficient for impairment listing decisions. For example, if the biological condition category is 'poor' based on the IBI value, and minimum total phosphorous sampling requirements are met, and the TP concentrations exceed the impairment threshold, the water would be listed for "degraded biological community" impairment with the pollutant "total phosphorus" listed as the "cause" of the impairment.

Additional targeted monitoring may be needed to identify a particular pollutant/impairment combination and could include supplemental physical and chemical data, as well as biological data, at additional monitoring sites to obtain adequate coverage of extent of impairment (Table 19). WDNR Biologists have knowledge of the factors that influence community response in rivers and streams. Those insights should be considered when selecting indicators to collect or when scheduling supplemental monitoring. Potential stressors and habitat surveys can help choose the appropriate parameters to be monitored and evaluated to confirm the impairment and to define the associated pollutant. Field collection, preservation and storage should follow procedures outlined in the WDNR Trend Reference Sites manuals and laboratory analysis should follow standard methods (Wisconsin State Lab of Hygiene, 1993).

[25] Aquatic Life Use was previously referred to as "Fish and Aquatic Life (FAL)". This was only a terminology change; no changes to the use definition were made.

Table 19. Additional parameters for river & stream impairment assessments.

Parameters		
• Alkalinity	• Hardness	• Sediment Chemistry
• Ammonia*	• Heavy Metals*	• Solids – Total Suspended
• Biochemical Oxygen Demand	• Land Use	• Solids – Settleable
• Chloride*	• Nitrogen – Total Kjeldahl	• Specific Conductivity
• Dissolved Oxygen*	• Nitrogen – (Nitrate & Nitrite)	• Temperature[%]
• Exotic Species – Abundance	• Organic Compounds*	• Toxicity – Ambient*
• Exotic Species – Presence/Absence	• Periphyton	• Toxicity – Sediment
• Flow	• pH*	• Transparency
• Habitat – Qualitative	• Phosphorus – Ortho	
• Habitat – Quantitative	• Phosphorus – Total*	

* = Numeric Water Quality Criteria are available in chs. NR 102 or 105, Wis. Adm. Code

Specific Protocols and Indicator Thresholds for Impairment Decisions

Biological Indicators

As in general condition assessments, biological indicators are also used to assess attainment of WQS and determine whether Aquatic Life uses are supported. Section NR 102.01(2) of Wis. Adm. Code explains the goal of WQS is to "protect the use of water resource for all lawful purposes… which includes the protection of public health and welfare and the present and prospective uses of all waters of the state for public and private water supplies, propagation of fish and other aquatic life and wild and domestic animals, domestic and recreational purposes, and agricultural, commercial, industrial, and other legitimate uses." Chapter 102.04(1)d Wis. Adm. Code provides narrative standards for the protection of fish and other aquatic life in surface waters, stating "Substances in concentrations or combinations which are toxic or harmful to humans shall not be present in amounts found to be of public health significance, nor shall substances be present in amounts which are acutely harmful to animal, plant or aquatic life." For streams and rivers, attainment of the narrative biological standards is assessed using the fish and macro-invertebrate indices described in the previous section. Biological indicator data collected from two or more sampling visits for a particular assessment unit (i.e. stream segment) are considered sufficient data to assess attainment of the narrative biological standards. The general condition category threshold for "poor" condition is used as the benchmark for evaluating attainment of WQS.

Total Phosphorus

For streams and rivers, TP can be linked as a pollutant causing biological impairment using WDNR's sampling protocol, which has been developed consistent with considerations of seasonality, timing and frequency of sample collection used by USGS for development of the TP criteria [s. NR 102.06(3) Wis. Adm. Code]. Waters should be sampled monthly over a 6-month period from May through October, ideally within the same year. Each sample should be collected approximately 30 days apart, with no samples collected within 15 days of one another. If more than one sample is available per month, the sample closest to mid-month should be used in the analysis. If one or more monthly samples are missed within a year, additional samples may be collected in subsequent years corresponding with the missed months (e.g., if July and August samples were not collected in the first year, they could be collected in the second year to make a complete data set). If multiple years of data are available, the three most recent years of data should be used. TP data collected for study-specific purposes as part of a targeted monitoring design (e.g., storm event sampling or targeted flow regimes) are not appropriate for assessment of attainment of the applicable TP water quality criterion.

A parametric statistical approach is employed to assess stream TP data against the applicable water quality criterion found in s. NR 102.06 of Wis. Adm. Code. This approach involves the calculation of a 90% confidence limit around the median of a TP sample dataset. A confidence limit is calculated using measures of sample size and variation to suggest with a specified level of certainty that the true population statistic (e.g., median) falls within a specified range of values. When sample values are normally distributed, the confidence interval around the median is identical to the confidence interval around the mean. Because phosphorus concentrations are usually log-normally distributed, the raw concentrations are log-transformed for the confidence interval calculation. The formula for the calculation is identical to the one shown in section 4.4 for lake phosphorus assessment.

WDNR uses automated database assessment packages to perform the calculations for sampling stations that meet the minimum data requirements for assessment purposes. Along with the automated assessment packages, an Excel spreadsheet template is also available for performing the calculations manually. Manual calculations of the statistical values may be required to assess data that was submitted during data solicitation (section 9.1 Requests for Data from the Public) but is not yet in the SWIMS database.

If the lower confidence limit (LCL) of the phosphorus dataset from a particular stream site exceeds the applicable criterion, and those data were representative of normal weather and hydrology, then the corresponding stream segment is considered to be exceeding the TP criteria. Two assessment paths lead to listing a stream or river for the pollutant TP in the standard impaired waters category, Category 5A. If the LCL exceeds the applicable TP criterion by two-fold (i.e., "overwhelming exceedance"), then biological confirmation of impairment is not required. However, if the LCL exceeds the criterion less than two-fold (under normal weather and hydrologic conditions), an F-IBI or M-IBI score indicating 'poor' biological condition sufficiently corroborates the AL use impairment. Waters that exceed TP criteria, but biological data are not available, or the biological assessment does not indicate impairment, will be placed in an impaired waters subcategory, Category 5P. These waters are assigned a high priority for biological data collection to determine appropriate future management actions. All Category 5P waters require TMDLs but will be given a low priority for TMDL development. These TP-related impairment listing scenarios are summarized in Table 8.

Delisting protocols for Total Phosphorus can be found in section 4.5 Lake Impairment Condition Assessment: Aquatic Life (AL) Use.

Chloride

Chloride is a concern for Wisconsin waters in part because of road salt used in the winter months. In surface waters chloride can be toxic to many forms of aquatic life. The chloride standards are set to protect aquatic life from chronic (long-term) and acute (short-term) toxicity. The criterion for chronic toxicity is 395 mg/L and for acute toxicity it is 757 mg/L. These criteria apply to AL use of streams, rivers, lakes, reservoirs, and impoundments. Chloride levels may be assessed at any time during the year because the aquatic community may be detrimentally impacted regardless of season; however, levels tend to be highest after snow melts. A waterbody is considered impaired for chronic toxicity if a 4-day average of the daily maximum values taken from 4 consecutive days exceeds the chronic criterion more than once in a three-year period[26]. For acute toxicity, a waterbody is considered impaired if the daily maximum exceeds the acute criterion more than once in a three-year period (Table 15). These criteria also apply to AL use of lakes, reservoirs, and impoundments. Chloride has been assessed on a systematic statewide basis since the 2014 assessment cycle and an automated assessment package was created in 2018.

Other physical/chemical indicators

For other physical/chemical parameters listed in Table 19 monitoring data are evaluated against minimum data requirements, specific thresholds and allowable exceedance frequencies as indicated in the table. If readily available data for the parameters listed are evaluated and determined to be insufficient (i.e., does not meet minimum data quantity requirements), but the limited data indicates a potential use impairment,

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[26] A chronic value determination for a water can be made if a single data point is available over a 4-day period. To assess whether the chronic criterion is being attained, 2 values would need to exceed the chronic criterion within a 3-year period, as identified in table 15.

the waterbody may be a designated as a "Watch Water," and assigned a higher priority for monitoring in the near future.

Table 20. Aquatic Life use impairment thresholds for rivers/streams

Note: Data are evaluated from within the most recent 10-year period for all parameters.

Parameters	Minimum Data Requirement[27]	Exceedance Frequency	Cold Waters	Warm Waters	Limited Forage Fish	Limited Aquatic Life
Conventional physical and chemical indicators						
Dissolved Oxygen	3 days of continuous measurements (no less than 1 sample per hour) in July or August collected from each of 2 separate calendar years.	Greater than 10% of values	<6.0 mg/L and <7.0 mg/L during spawning season	<5.0 mg/L	<3.0 mg/L	<1.0 mg/L
Temperature	10 discrete daily values[28] or days of continuous temperature data collected within a given calendar month to assess against acute and sub-lethal criteria, respectively.	Greater than 10% of daily maximum values or any weekly average temperature value in a calendar month exceeds acute criteria or sub-lethal criteria, respectively.	See Table 2 of NR 102.25(2) of Wis. Admin. Code for acute and sub-lethal temperature criteria by calendar month for non-specific waters			
pH	10 discrete daily values	Greater than 10% of values within a continuous sampling period or for instantaneous w/in season	Outside the range of 6.0 to 9.0 standard units (SU), or change is > 0.5 SU outside natural seasonal maximum (mean) and minimum (mean)			
Total Phosphorus[29]	6 samples monthly from May through October	Lower 90% confidence interval of the sample median exceeds threshold	≥0.100 mg/l for rivers; ≥0.075 mg/l for streams			
Biological indicators						
Fish IBI	1 value when used in combination with TP data. For a standalone bio-assessment, 1 value from each of 2 years within 5 years	1 value when used in combination with TP data. For a standalone AL listing, average value from 2 samples across 2 years	See "poor" condition thresholds in Table 9			
Macroinvertebrate IBI	1 value when used in combination with TP data. For standalone bio-assessment, 1 value from each of 2 years within 5 years	1 value when used in combination with TP data. For standalone AL listing, average value from 2 samples across 2 years	See "poor" condition thresholds in Tables 10 and 11			

[27] Smaller datasets may be considered in certain cases, such as a high magnitude of exceedance.
[28] Discrete values refer to samples collected on separate calendar days.
[29] One 'poor' F-IBI or one 'poor' M-IBI is also required to corroborate the impairment of the FAL use for standard impaired waters Category 5A listings. Streams exceeding TP criteria alone will be placed in an impaired waters subcategory, Category 5P.

Table 21. Aquatic Life use aquatic toxicity impairment thresholds for rivers/streams.

Aquatic Toxicity-Based indicators			
Acute aquatic toxicity indicators	**Minimum Data Requirement**	**Exceedance Frequency**	**Criteria Table Reference**
Cadmium*, Chromium$^{(3+)}$*, Copper*, Lead*, Nickel*, Zinc*, Pentachlorophenol, Selenium, and Ammonia	2 values within a 3-year period	Maximum daily concentration not exceeded more than once every 3 years	Criteria in NR 105.05 Wis. Adm. Code
Arsenic$^{(+3)}$*, Chromium$^{(+6)}$*, Mercury$^{(+2)}$*, free Cyanide, Chloride, Chlorine (total residual), Gamma – BHC, Dieldrin, Endrin, Toxaphene, Chlorpyrifos, and Parathion			
Chronic aquatic toxicity indicators			
Cadmium*, Chromium$^{(3+)}$ *, Copper*, Lead*, Nickel*, Zinc*, Selenium, Ammonia and Pentachlorophenol	2 values within a 3-year period	Maximum 4-day average concentration not exceeded more than once every 3 years	Criteria in NR 105.06 Wis. Adm. Code
Arsenic$^{(+3)}$*, Chromium$^{(+6)}$*, Mercury$^{(+2)}$*, free Cyanide, Chloride, Chlorine (total residual), Dieldrin, Endrin, and Parathion			

**total recoverable form*

5.4 Stream and River Impairment Condition Assessment: Recreation Use

Federal criteria for *E. coli* were developed after consideration of risk to the swimming public. All of the data used to establish the federal criteria were collected from swimming beaches. In general, flowing rivers and streams in Wisconsin do not provide comparable recreational activities for full body immersion. For those water bodies, WDNR utilizes the long-standing water quality criterion for fecal coliform that is reflected in s. NR 102.04(5), Wis. Adm. Code. That section reads:

> (a) *Bacteriological guidelines.* The membrane filter fecal coliform count may not exceed 200 per 100 ml as a geometric mean based on not less than 5 samples per month, nor exceed 400 per 100 ml in more than 10% of all samples during any month.

When a flowing stretch of a river or stream is included on the proposed Impaired Waters List, the pollutant is listed as fecal coliform and the impairment is identified as "Recreational Restrictions – Pathogens." In many instances where fecal coliform counts are high, *E. coli* data or other pathogen data are also collected for streams and rivers and may be used in lieu of or supplementary to fecal coliform data to make best professional judgment decisions to list or not list the waterbody as impaired.

5.5 Stream and River Impairment Condition Assessment: Wildlife Use

Wildlife criteria protect wildlife that consume surface water and aquatic organisms. Table 13 shows the wildlife criteria in NR 105.07(1), Wis. Adm. Code.

6.0 Public Health and Welfare Uses – Applicable to all Waterbody Types

Wisconsin's water quality standards specify that all surface waters shall be suitable for supporting the Public Health and Welfare designated use. To protect the Public Health and Welfare use of waters of the state, water quality criteria were established, including temperature, taste and odor criteria, as well as human health criteria in ss. NR 105.08 and 105.09, Wis. Adm. Code, to protect humans from adverse effects resulting from contact with or ingestion of surface waters and from ingestion of aquatic organisms taken from surface waters. The human threshold criteria (HTC) were derived for those toxic substances for which a threshold dosage or concentration can be estimated below which no adverse effect or response is likely to occur. The human cancer criteria (HCC) are the maximum concentrations of substances established to protect humans from an unreasonable incremental risk of cancer resulting from contact with or ingestion of surface waters and from ingestion of aquatic organisms taken from surface waters.

Waters for which available datasets meet minimum data requirements are assessed against the applicable criteria, which may vary depending on the assigned Aquatic Life use and whether the waterbody is a public water supply. Waters with two or more discrete values within a consecutive 3-year period (within the current 10-year assessment period) will be assessed against the applicable criteria. Discrete values refer to samples collected at least 30 days apart. One exceedance within a 3-year period is allowed, while waters with two or more HTC or HCC criteria excursions within a 3-year period fail to meet the criteria and the Public Health and Welfare use is deemed not supported.

6.1 Fish Consumption Use Assessment

Waterbodies may be designated as impaired on the 303(d) list based on the level of fish consumption advice, which, in Wisconsin, is due primarily to mercury, PCBs, dioxin and furan congeners, and Perfluorooctane sulfonate (PFOS). In 1998, 241 waters were added to the 303(d) list in Category 5B[30], "Waters Impaired by Atmospheric Deposition of Mercury," because mercury-based fish consumption advisories had been issued for these specific waterbodies based on advisory protocols then used by Wisconsin (1985 and 1986 Mercury Protocols).

In 2001, Wisconsin adopted a statewide general advisory that applies to all (non-Great Lakes) waters of the state based on statewide distribution of mercury in fish and species differences in mercury concentrations. The statewide general advisory eliminated the need for many of the pre-2001 advisories because the equivalent of more stringent advice now applied through the general advisory. Exceptions to the general statewide advice apply to some species of fish from specific waters where higher concentrations of mercury, PCBs or other chemicals require advice more stringent than the general advisory. Since 2002, the 303(d) list has been updated based on changes made to the list of specific advisory waters.

Since the 2012 impaired waters update, a waterbody is proposed for removal from the 303(d) list when the most recent advisory update indicates that only the statewide general advisory is necessary for concentrations of bioaccumulating chemicals that are of concern in Wisconsin fish. The waters defined as impaired waters are those with specific contaminant data for game and panfish species that require advice more stringent than the statewide general advice based on examination of data in conjunction with WDNR of Health Services. Appendix C lists the fish tissue contaminant thresholds that are used when developing fish consumption advisories.

Specific waters are proposed for de-listing where fish samples are collected and tested for the appropriate chemicals and where the general statewide advisory is determined to be adequate and exceptions are not

[30] See Chapter 8 on page 59 for an explanation of Integrated Report Assessment Categories.

necessary based on an evaluation of the concentrations of mercury, PCBs, dioxin/furans, or other chemicals using Wisconsin's fish advisory protocols. The general fish consumption advisory will still apply to these waters, but they will no longer be included on the 303(d) list.

Wisconsin Departments of Natural Resources and Health Services jointly manage the fish contaminant monitoring and advisory programs. The monitoring strategy for fish contaminants varies by the pollutant and the waterbody (see Wisconsin's Water Division Monitoring Strategy). WDNR fisheries staff conducts the fish sampling supported by a variety of fisheries funds. The Wisconsin State Laboratory of Hygiene supports most chemical analyses through general revenue and an agreement with the WDNR. Some EPA funds are used for supplies, lab and freezer rentals, advisory publications, and special analyses.

More information about the specific consumption advisory can be found in the publication: Choose Wisely, A Healthy Guide for Eating Fish in Wisconsin (PUB-FH-824 2016 or subsequent years.) It is available on line at http://dnr.wi.gov/topic/fishing/consumption/.

6.2 Contaminated Sediment Assessment

Waterbodies that have sediment deposits that are known to have toxic substances that exceed state water quality criteria for ambient water (as specified in ch. NR 105, Wis. Adm. Code) will be included on the Impaired Waters List. These waters may be identified through various monitoring activities, including routine water quality monitoring, sediment analysis, and collection of fish tissue. In addition to a comparison to the water quality criteria found in ch. NR 105, Wis. Adm. Code, WDNR compares the concentrations of commonly found, in place contaminants to the values outlined in a sediment quality guidance document *Consensus-Based Sediment Quality Guidelines, WT PUB- 732, 2003* (See Appendix E; https://dnr.wi.gov/files/PDF/pubs/rr/RR088.pdf). The guidance was developed through an assimilation of results from multiple published effects-based toxicity testing to freshwater benthos, and serves as part of a tiered approach to evaluating potential ecological and human health risks at sites under evaluation for various reasons.

6.3 Public Water Supply Use Assessment

The Public Health and Welfare designated use found at s. NR 102.04 (7), Wis. Adm. Code, contains a designation for public drinking water supply. The public water supply use is a subcategory under the Public Health and Welfare designated use. Chapter NR 104, Wis. Adm. Code, contains the listing of specific waterbodies that are to meet "the public water supply standard." Of the waters assigned the public water supply use, Lakes Winnebago, Superior and Michigan (including Green Bay) are the surface waters currently used as a source for a public water supply.

Surface water quality standards were established to protect public water supply (PWS) source waters to the extent that the PWS can meet the Safe Drinking Water Act (SDWA) standards using only conventional treatment technologies as defined by the SDWA. The PWS use will be assessed, where data that meet minimum data quantity and quality requirements are readily available, by comparing ambient source (i.e., raw) water data or PWS facility intake data against applicable human health surface water quality standards in ch. NR 105, Wis. Adm. Code, and additional water quality indicators for which surface water quality standards are not yet established. Assessment indicators and methods are described below.

Cyanobacteria (Blue-green Algae) Toxins – There are no federal or state regulatory standards for cyanobacteria toxins (cyanotoxins) in drinking water. However, the World Health Organization (WHO) adopted a provisional drinking water guideline value of 1.0 µg/L for microcystin-LR (WHO 1998). Since the cyanobacteria thresholds are based on acute exposures, assessment methods will be based on a maximum concentration not to be exceeded. Source waters with finished water samples showing two or more excursions in a 3-year period above the WHO guideline for microcystin-LR (1.0 µg/L) will be identified as impaired and not supporting the PWS use. The assessment will also consider whether the dataset is representative of the current conditions of the source water. Quality assured sample data from ambient (raw) water or PWS intakes will be evaluated from the most recent 10-year period of record; two or more discrete values within a consecutive 3-year period are required to assess against the applicable criteria. Discrete samples are those collected at least 30 days apart; multiple samples collected within a 30-day period will be averaged.

Nitrate – Elevated levels of nitrate can cause acute health effects. The SDWA finished water standard of 10 mg/L will be applied as a maximum concentration not to be exceeded. Using this indicator, the PWS use is not supported when two or more discrete samples exceed the SDWA Maximum Contaminant Level (MCL) standard within a 3-year period. Quality assured sample data from ambient (raw) water or PWS finished water will be evaluated from the most recent 10-year period of record; two or more discrete values within a consecutive 3-year period are required to assess against nitrate standard. Discrete samples are those collected at least 30-days apart; multiple samples collected within a 30-day period will be averaged. Source waters with nitrate sample datasets showing concentrations exceeding 5 mg/L will be identified as "watch waters" and prioritized for additional monitoring to evaluate nitrate concentration trends.

Cryptosporidium – Public water systems are required to collect *Cryptosporidium* raw water samples at a minimum frequency of monthly over a two-year period at their point of intake in order to fulfill SDWA regulations. The maximum rolling annual average *Cryptosporidium* concentration is used to place the public water system in SDWA Bin classifications of 1 through 4. Concentrations of *Cryptosporidium* greater than or equal to 1.0 oocysts/L place the system in Bin 3 or 4 and require additional treatment beyond conventional or source water controls in the watershed. Therefore, the PWS use will be deemed as not supported for source waters when one or more public water supply systems fall in Bins 3 or 4.

Pollutants with Human Health-based Water Quality Criteria – Human health criteria in ss. NR 105.08 and NR 105.09, Wis. Adm. Code, are established to protect humans from adverse effects resulting from ingestion of surface waters of the state and from ingestion of aquatic organisms taken from surface waters of the state. The human threshold criteria (HTC) are derived for toxic substances that have a threshold dosage or concentration below which no adverse effects or responses are likely to occur. The human cancer criteria (HCC) are the maximum concentrations of substances established to protect humans from an unreasonable incremental risk of cancer resulting from contact with or ingestion of surface waters of the state and from ingestion of aquatic organisms taken from surface waters of the state. The applicable HTC and HCC are determined both by a waterbody's Aquatic Life use subcategory and whether the waterbody is a public water supply.

Source waters having readily available pollutant datasets containing two or more discrete sample values within a consecutive 3-year period (from the current 10-year assessment period) will be assessed against the applicable HTC or HCC criteria. Discrete samples are those collected at least 30-days apart; multiple samples collected within a 30-day period will be averaged. Source waters with two or more excursions in a 3-year period may be identified as impaired and not supporting the PWS use.

Taste and Odor-producing Substances – Available information regarding non-natural substances producing taste and odor will be assessed against the taste and odor criteria found in NR 102.04(8)(b), Wis. Adm. Code. In addition, the public water supply use will be deemed not supported when taste and odor substances are present in quantities requiring additional treatment by the public water supply to prevent taste and odor problems.

7.0 Making a Decision to List or Delist Waterbodies

Once data have been assessed to determine whether any parameters indicate impairment of a waterbody, a decision to list a waterbody as impaired or to delist a waterbody should be made. There are several nuances to this decision that are discussed in this chapter. These include resolution of conflicting results from different parameters on a waterbody, identification of which Use Designations are impaired, determination of the appropriate EPA category, and identification of "Causes" and "Sources" of impairment.

When minimum data requirements are met, an attainment decision should be made and documented. When a decision is made to not list a waterbody due to insufficient data, where limited data show criteria excursions, the water is identified as a "Watch Water," as defined in section 7.4 Watch Waters, and prioritized for future monitoring to collect sufficient data for future assessment. All assessment results and impaired waters listing details are documented in the WATERS database.

7.1 Independent Applicability & Tools to Resolve Data Conflicts

Under Federal guidance, a water shall be listed on the Impaired Waters List if data is reflective of current conditions, data has met minimum data requirements, and the water does not meet WQS, including water quality criteria, designated uses, and/or antidegradation. This decision philosophy is referred to as *independent applicability*, consistent with the CWA that protects biological, chemical, and physical integrity of surface waters. However, EPA recognizes that there are certain situations in which factors beyond a strict interpretation of Independent Applicability should be considered to make the most appropriate listing decision. When assessing whether a water is attaining narrative WQS, for example, a suite of indicators are often used. Accordingly, EPA allows states to formulate specific decision rules pertaining to circumstances under which one type of parameter should be given a greater 'weight' than others.

Independent Application Decision Matrix for Multiple Assessment Indicators

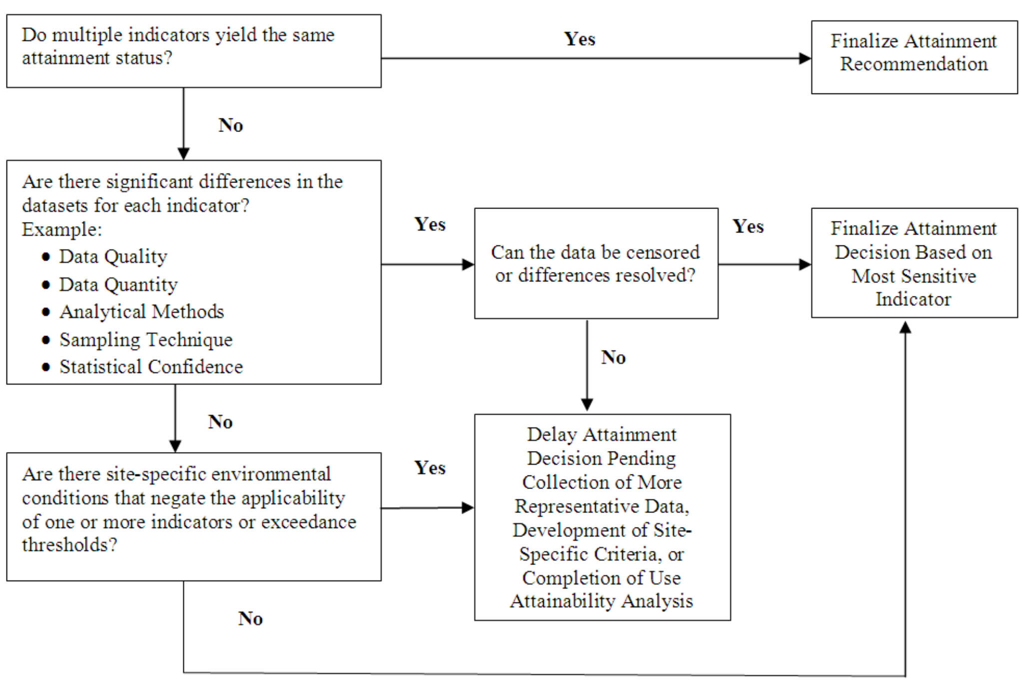


Figure 15. Independent Application Matrix.

Wisconsin has developed decision rules that use a hierarchy of indicators for certain parameters, which are described within the Lakes and Rivers & Streams chapters of this guidance document.

If one of the WQS are not met, but multiple data sets produce conflicting results (some indicating impairment and some not), WDNR staff should review all available data to assist in making an attainment decision. There are several factors biologists may use to resolve these differences to arrive at a listing decision. A decision matrix describes the process for not making attainment decisions using independent application (Figure 15). Cases where this process is used will be rare and should be well documented for that water in the WATERS database.

Data quality differences
If one parameter indicates impairment but another does not, differences between the two data sets in data quality, data quantity, analytical methods, sampling technique or statistical confidence may provide reason to weight one set of data more heavily than another.

Site-specific factors
Natural background levels of a pollutant may be higher than impairment thresholds or uncontrollable factors may cause an exceedance of WQS. In these circumstances, WDNR will determine whether criteria exceedance are reasonably expected to be due to natural or uncontrollable causes, as defined in the "Six Factors" of Use Attainability Analysis [40 CFR 131.10(g)]. If assessment documentation supports that impairment is due to natural or uncontrollable factors, a Use Attainability Analysis (UAA) should be pursued to modify the Designated Use and/or associated criteria. However, a water with suspected naturally occurring pollutant levels that exceed applicable water quality criteria should be placed on the Impaired Waters List under Category 5C, until the appropriate designated use and/or site-specific water quality criteria have been approved by WDNR and EPA. Category 5C waters are those that are identified as impaired, but the cause of the impairment may be attributed to natural or uncontrollable source(s).

Weight of Evidence
In certain cases where data sets conflict with one another, states may apply a "weight of evidence" approach. This approach helps define the extent of the problem based on how it impacts the Designated Use and allows biologists to consider aspects of the data that might indicate whether one data set should be weighted more greatly than another.

In all cases, Department staff will look for corroborating information, such as the various habitat and biological indices and water chemistry data. If the suite of available data does not suggest an evident impairment, then the water will not be listed, but will be recommended for additional monitoring as resources allow. WDNR will provide a rationale for those cases where data are available that show that a water quality criterion has been exceeded, but the water has not been recommended for the impaired waters list. In those cases, the indicator has not reached the magnitude, duration or frequency to warrant placing a waterbody on the list or the available data from a particular indicator are not representative of current conditions.

Hierarchy of Indicators
In some situations, *a hierarchy of the indicators may be appropriate*. For example, biological indicators (e.g., fish or macroinvertebrate IBI) for assessment of the Aquatic Life use may have precedence over physical or chemical indicators in the impairment decision process, because they are direct measures of health of aquatic life. However, this hierarchical approach should be used with caution, knowing that exceedance of chemical indicators may correspond to a more recent event that was not reflected in the biological community data due to differences in collection periods or delays in community response. In such a case, a decision to rely on a hierarchical approach would be inappropriate.

When assessing waters against the applicable phosphorus criteria, biological data are used in combination with phosphorus data to determine whether the Aquatic Life use is currently impaired. If biological impairment is observed, the water is placed in the standard impaired waters category (5A). If the water exceeds phosphorus criteria but biological impairment is not observed, the water is placed in an impaired water subcategory (5P) that is given a lower priority for management actions, until biological impairment is confirmed.

7.2 Professional Judgment

WDNR staff most familiar with a waterbody should be directly involved in the assessment decision. Staff knowledge and experience along with the factors that influence water quality should be considered when reviewing and interpreting available data. Professional staff should explore a myriad of issues to determine the most relevant and appropriate data to use for attainment decisions, including: data quality, frequency and magnitude of exceedances, weather and flow conditions during sample collection, anthropogenic or natural influences on water quality in the watershed, etc. If any available data is not used because of professional judgment, clear documentation of the reasons for doing so should be included in the final attainment decision. Again, whether a waterbody is listed as impaired, or the decision has been made not to list a waterbody, all decisions should be *well documented* within the database and future management recommendations will be noted on waters that were not listed (for example, a formal use designation change is needed in order to list the water as impaired, and a recommendation would be made in WATERS to reflect this need).

Two specific review stages occur during the assessment process when regional water resource biologists review the preliminary assessment results. The first review is a data review of the automated database assessment packages. The package results include a series of downloadable reports and spreadsheet outputs for some assessment parameters, which are provided to biologists for review. At that time, reviewers may document justification for a different assessment result based on data quality, additional data and/or waterbody classification errors. After incorporating all assessment and listing modifications from the data review, a Professional Judgment Team will review the draft assessment results and make recommendations for any needed modifications. The following questions may be considered during the professional judgment review stage:

- Are the data from appropriate weather and flow conditions, or are they limited to critical hydrological regimes (low and high flows)? If data are available only from extreme weather years (as defined in Section 2.5), should that dataset be supplemented with data from current conditions before making an assessment decision?
- Are data representative of current water quality conditions?
- Have land uses or point sources changed substantially since the data were collected?
- If the minimum data requirements are not met, do the limited data provide overwhelming evidence of impairment (e.g., phosphorus dataset does not meet minimum data requirements, but biological impairment has been documented, or the phosphorus criterion is exceeded by double)?

7.3 Threatened Waters

Wisconsin recognizes *threatened* waters as defined by the United States Environmental Protection Agency (EPA):

> *Any waterbody of the United States that currently attains water quality standards, but for which existing and readily available data and information on adverse declining trends indicate that water quality standards will likely be exceeded by the time the next list of impaired or threatened waterbodies is required to be submitted to EPA.*

Waters identified as *threatened* waters become a formal part of the Impaired Waters List, with all of the ramifications associated with impaired waters. Currently no guidance exists on how to formally list *threatened* waters as impaired, however, waters that fall into this category may be evaluated on a case-by-case basis. A biologist would have to provide sufficient data and information (e.g., 5-10 years of data and multiple samples per year to run a regression analysis) that clearly shows a "declining trend" to predict that the water would be impaired by the next listing cycle. If such significant data exists, the water could be considered for listing as threatened on the Impaired Waters List.

7.4 Watch Waters

Watch Waters are those for which limited data indicate potential impairment, but insufficient data are available to make a final impairment decision, and, therefore, are identified for further monitoring. These waters are not included on the Impaired Waters List due of circumstances warranting further observation or evaluation.

For example, a water may be designated as a Watch Water if water quality data indicating impairment were collected from unrepresentative "extreme weather" periods, as defined in Section 2.5, resulting in insufficient data to assess. Watch Water status is also designated when phosphorus data are assessed for a particular water but a "clear" decision cannot be made (i.e., 90^{th} percent confidence interval of the phosphorus sample concentration data overlaps the criterion). WisCALM guidance defines a "clear" exceedance of the phosphorus criteria as the lower 90^{th} percent confidence interval of a phosphorus sample concentration dataset that exceeds the applicable criterion. Conversely, the phosphorus criteria are "clearly met" when the upper 90^{th} percent confidence interval of the phosphorus sample concentration data is below the applicable criterion.

7.5 Identifying Sources of Impairment

When a water is deemed impaired, the potential source(s) causing the impairment should be identified. Impairment sources affect which parameters are monitored, what model should be used for analysis and what type of restoration activities would be best on that individual water. In the WATERS database under the "WDNR Impaired Waters Category," sources may be entered. Some possible sources of impairment include:

Atmospheric Deposition: This source category includes waters with fish consumption advisories (FCAs) caused by atmospheric deposition of mercury. Atmospheric deposition is currently only applicable to mercury and PCBs but could be identified as a source for other in the future.

Contaminated Sediment: Waters identified through various monitoring activities, sediment core analysis, and collection of fish tissue that exceed ambient water quality criteria for toxics as specified in ch. NR 105, Wis. Adm. Code. In addition, this may include waters where contaminated sediments contain pollutant concentrations that will cause "probable effects" in biological organisms based on guidelines outlined in the "Consensus-Based Sediment Quality Guidelines: Recommendations for Use and Application" (Appendix E).

Physical Habitat: Waters where designated uses are not being met due to a physical habitat degradation, including anthropogenic stream channel alterations, such as a dam installation, stream channelization, bank erosion, and riparian zones disturbance.

Point Source Dominated: Waters are categorized as point source dominated when the impairment is a result of a current discharge from an existing point source. The Wisconsin Pollutant Discharge Elimination System (WPDES) Permit Program issues and evaluates permits for point sources to assure the attainment of standards at the time of permit issuance. Existing laws and administrative rules including the WQS and WPDES permit rules preclude the issuance of a permit if it will not attain WQS. Waters in this category are likely between permit cycles or may have obtained a variance to the WQS under current law.

Nonpoint Source (NPS) Dominated: Waters in which the impairment is a result of nonpoint source runoff, including urban stormwater runoff.

Nonpoint Source/Point Source Blend: Waters are placed in this category when impairments exist due to both point source contributions and nonpoint source runoff. Listing a waterbody which is impacted by a point source does not imply that the source is not meeting all the requirements in its discharge permit, but only indicates that a TMDL is needed to determine relative contributions by each of the sources and what additional requirements may be needed.

7.6 Pollutant-Impairment Combinations

Pollutant and impairment listings are derived from the parameter assessed for each waterbody type. There are several pollutant-impairment combinations that have been in common use since the 2012 assessment cycle. Table 22 shows the common parameters assessed and the resulting pollutant and/or impairments associated with an exceedance. Figure 16 and Figure 17 are examples of an entire waterbody assessment.

Table 22. Resulting pollutant and/or impairment from an exceedance of each parameter. These are not all the possible parameters assessed, but some of the most common.

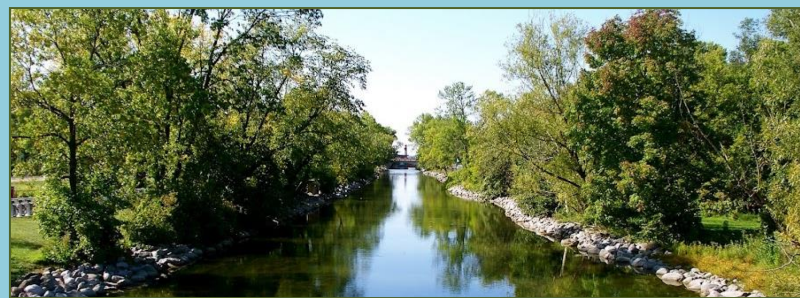
Parameter	Pollutant	Aquatic Life Use Impairment	Recreation Use Impairment
Total Phosphorus	Total Phosphorus	Impairment Unknown	Impairment Unknown
Total Phosphorus (Overwhelming Exceedance)	Total Phosphorus	High Phosphorus Levels*	High Phosphorus Levels *
Chlorophyll-*a*	--	Eutrophication	Excess Algal Growth
mIBI	--	Degraded Biological Community	--
fIBI	--	Degraded Biological Community	--
Chloride	Chloride	Chronic Aquatic Toxicity; Acute Aquatic Toxicity	--
Temperature	--	Elevated Water Temperature	--
E. coli	*E. coli*	--	Recreational Use Restrictions

*The term “High Phosphorus Levels” was previously called “Water Quality Use Restrictions” which was used from cycles 2012 – 2018 to indicate an overwhelming exceedance of the total phosphorus criteria.

Figure 16. Example of assessing a stream for multiple uses with multiple parameters, to determine the overall waterbody listing.

Waterbody

Leafy Creek



Uses

Recreation	Public Health	Aquatic Life
		

Parameters

Parameter	Recreation	Public Health	Aquatic Life
Total Phosphorus	---	---	Meets Criteria
mIBI	---	---	Meets Criteria
fIBI	---	---	Meets Criteria
Temperature	---	---	Meets Criteria
Chloride	---	---	Meets Criteria
E. coli	Meets Criteria	---	---
Mercury	---	Exceeds Criteria	---
PCBs	---	Meets Criteria	---

Assessment

	Recreation	Public Health	Aquatic Life
Use Attainment	Attaining	Not Attaining	Attaining
Overall Waterbody Status	Impaired for Mercury in fish tissue (Category 5B).		

Figure 17. Example of assessing a lake for multiple uses with multiple parameters, to determine the overall waterbody listing.

Waterbody

Mud Lake

Uses

Recreation	Public Health	Aquatic Life
		

Parameters

Parameters	Recreation	Public Health	Aquatic Life
Total Phosphorus	Exceeds Criteria	---	Exceeds Criteria
Chlorophyll-*a*	Exceeds Criteria	---	Exceeds Criteria
Temperature	---	---	Meets Criteria
Chloride	---	---	Meets Criteria
E. coli	Meets Criteria	---	---
Mercury	---	Meets Criteria	---
PCBs	---	Meets Criteria	---

Assessment

Assessment	Recreation	Public Health	Aquatic Life
Use Attainment	Not Attaining	Attaining	Not Attaining
Overall Waterbody Status	Impaired for Total Phosphorus, Excess Algal Growth, and Eutrophication (Category 5A).		

7.7 Delisting Impaired Waters

Waters and/or associated pollutants and impairments are delisted from the state's impaired waters list when the state determines, and the EPA approves, that the waters are no longer impaired, or a particular pollutant impairment combination should be removed. A water will not be delisted until all previously listed pollutant/impairment combinations have been removed because applicable WQS are attained. WDNR proposes to de-list a waterbody and/or associated pollutants and impairments from the Impaired Waters List when contemporary, representative, and high-quality data warrant delisting. However, when a change to a water quality standard (e.g., site-specific criteria) has been approved by EPA and the waterbody now meets the revised criterion, WDNR may propose to remove the water and/or associated pollutants and impairments from future lists.

Water No Longer Impaired

WDNR delists waters that have been restored. New monitoring data will be collected to evaluate the response of the waterbody to some sort of implementation or restoration strategy. Waters will be assessed through the same process identified as listing a waterbody on the 303(d) Impaired Waters List and must meet WQS to be removed from the list.

If a portion of a previously listed water is later determined to be no longer impaired, while other portions remain impaired, the originally listed water may be subdivided into multiple assessment units to account for these differences in attainment status. Guidance on delineating, subdividing and aggregating assessment units is provided in Section 2.6 on page 16.

Water Listing Validation Found No Impairment

WDNR has identified some waters on historical Impaired Waters Lists that may be inappropriately listed. Common reasons include improper documentation of a past assessment, misidentification of a waterbody, and/or incorrect description of the reach and its specific location within a watershed. In those cases, contemporary information will be documented and WDNR may propose to delist those waters if the most recent assessment indicates all designated uses are achieved.

EPA Approved TMDL or Alternative Restoration Plan

When EPA approves a TMDL or alternative restoration plan, the water pollutants covered by the TMDL or plan are proposed for removal from EPA-approved list of impaired waters that require a TMDL (Category 5 waters). However, the water is still considered impaired until applicable WQS have been met. Waterbodies having completed TMDLs are moved to Category 4A and ones with alternative plans are moved to Category 4B (Table 23). These Category 4 waters are considered the Restoration Waters List. Once the water is restored and meets applicable water quality criteria, it may be moved to Category 2 and the Healthy Waters List.

7.8 Decision Documentation

A primary goal of the WDNR is to document all impaired waters decisions, verify the current impaired waters list, and make this information accessible to the public. It is critical that WDNR staff fully document their impaired waters listing recommendations, supporting materials, and justification of their decisions, including any professional judgment used to support those decisions. As a part of this process, it is also important to document assessment decisions for waterbodies that were evaluated but deemed fully supporting assessed uses. The WATERS data system for monitoring and assessment data provides WDNR staff with a systematic location and process for documenting assessment decisions.

Data contained in these data systems are available for the public via the WDNR Surface Water Data Viewer. Information such as monitoring stations, Impaired Waters, WPDES permits, etc. can be accessed from this site. WDNR also maintains dynamic webpages created for Impaired Waters where the public can find water quality monitoring data, pollutants/impairments of concern, TMDL status, and possible management solutions for improving the waterbody. The Impaired Waters Search Tool may be accessed at the following website: http://dnr.wi.gov/water/impairedSearch.aspx.

Assessments of non-conventional parameters or those that deviate from standard WisCALM guidance should be documented in the WATERS database or on the standardized documentation form (Appendix B) and include a justification or case-specific reason for diverging from the assessment guidance. An electronic documentation form is available on request; please send requests to DNRImpairedWaters@wisconsin.gov.

8.0 Integrated Report Listing Categories

One of the elements of the Integrated Report (IR) is defining IR listing categories (Table 23) for each waterbody or assessment unit to communicate work conducted under the use designation, assessment and restoration elements of the WQS program. Wisconsin's IR listing categories loosely follow federal categories identified in the 2008 EPA Integrated Reporting Guidance document. These are the same categories as described in Section 3.3 and in APPENDIX A. Quick Reference Section.

Table 23. Integrated Report (IR) Listing Categories and associated lists.

List	IR Category	How Categories Are Used in Wisconsin
Healthy Waters	Category 1	All designated uses are met, no use is threatened, and the anti-degradation policy is supported. This category requires that all designated uses have been assessed for a given water.
Healthy Waters	Category 2	Available information indicates one or more designated uses are met. This category is applied to waters that have been assessed and considered fully meeting one or more designated uses and is also applied in Wisconsin to waters that have been restored and removed from the impaired waters list.
	Category 3	There is insufficient available data and/or information to assess whether a specific designated use is being met or if the anti-degradation policy is supported. This category is also used for situations where the state has not yet had time or resources to analyze available data.
Restoration Waters	Category 4: Waters where a Total Maximum Daily Load (TMDL) is approved by EPA or not required.	
Restoration Waters	Category 4A	All TMDLs needed for attainment of water quality standards have been approved or established by EPA. This does not mean that all other designated uses have been evaluated and found to be meeting their designated use.
Restoration Waters	Category 4B	Required control measures are expected to achieve attainment of water quality standards in a reasonable period of time. Environmental Accountability Projects or 9-Key Element Plans may be proposed as an alternative to TMDL development.
Restoration Waters	Category 4C	A waterbody where the impairment is not caused by a pollutant. Pollution is defined by EPA as the human-made or human-induced alteration of the chemical, physical, biological, and radiological integrity of water [Section 502(19)].
Impaired Waters	Category 5: Waters where a TMDL is required.	
Impaired Waters	Category 5A	Available information indicates that at least one designated use is not met or is threatened, and/or the anti-degradation policy is not supported, and one or more TMDLs are still needed.
Impaired Waters	Category 5B	Available information indicates that atmospheric deposition of mercury has caused the impairment of the water. The water is listed for a specific advisory and no in-water source is known other than atmospheric deposition.
Impaired Waters	Category 5C	Available information indicates that non-attainment of water quality standards may be caused by naturally occurring or irreversible human-induced conditions.
Impaired Waters	Category 5P	Available information indicates that the applicable total phosphorus criteria are exceeded; however, biological impairment has not been demonstrated (either because bioassessment shows no impairment or because bioassessment data are not available).
Impaired Waters	Category 5W	Available information indicates that water quality standards are not met; however, the development of a TMDL for the pollutant of concern is a low priority because the impaired water is included in a watershed area addressed by at least one of the following WDNR-approved watershed plans: adaptive management plan, adaptive management pilot project, lake management plan, or CWA Section 319-funded watershed plan (i.e., nine key elements plan).

Placing Assessment Units in Categories

Evaluated waters are placed in Category 3 unless sufficient data or information is available to move the water from a Category 3 to a different group. Waters that meet one or more designated uses -- and have no uses impaired will be included in Category 2. For example, if a waterbody was previously listed as impaired, but, subsequently restored and removed from the impaired waters list, it may then be placed in Category 2. This category cannot be used for situations in which one or more use designations have been restored but other use designations remain impaired. Waters will be placed in Category 2 after WisCALM guidance has been applied and the water has been fully assessed through an impaired waters de-listing process and determined to be meeting applicable WQS.

Moving Assessment Units between Categories

Waters are moved from one category to another during updates to the assessment database by water quality biologists and program coordinators. Once an assessment has been conducted the water will be moved from Category 3, to the updated category. This process usually occurs once a year during the update of the state's water assessments during basin plan updates.

Assessment Units with multiple pollutant/impairment listings

Wisconsin uses one category per water, as well as a category for each pollutant/impairment listing combination. Because of this, the waterbody is placed in the more protective or restrictive category available. For example, if a waterbody is listed for two use impairments (e.g., Recreation and Aquatic Life) and one of the two remain impaired while the other is restored, the waterbody will remain in an impaired water category (i.e., Category 5).

Table 24. Example of a waterbody assessment with multiple pollutant listings and how that translates into the overall waterbody category listing.

Use	Pollutant	Pollutant-Category	Overall Waterbody Category
Aquatic Life	Total Phosphorus	Category 4A	Category 5A
Recreation	E. coli	Category 5A	
Fish Consumption	Mercury	Category 5B	

Impaired Waters List

Listings determined to be in Category 5 are part of the **Impaired Waters List**. Listings covered by a TMDL or an alternative plan, ones in Category 4, are part of the **Restoration Waters List**. Category 4 waters were considered part of the impaired waters list prior to the 2020 assessment cycle. While Category 4 waters are not yet restored they are already addressed by an EPA-approved plan. Waters in Categories 1 or 2 are part of the **Healthy Waters List**. These lists were distinguished to better convey the status of assessments, listing, and restoration.

8.1 Priority Ranking for TMDL Development

Waters on the Impaired Waters List will be ranked by priority for Total Maximum Daily Load (TMDL) development. A TMDL is an analysis that determines how much of a pollutant a waterbody can assimilate before it exceeds Water Quality Standards. Federal law requires that TMDLs be developed for impaired waters.

TMDL prioritization is based on [Wisconsin's Water Quality Restoration and Protection Prioritization Framework [PDF]]() document. Prioritization currently focuses on two pollutants, total phosphorus (TP) and total suspended solids (TSS) as these are two of the most commonly identified pollutants on the impaired waters list. Priority areas are identified through systematic and objective modeling analysis that identified parts of the state experiencing the most ecological degradation and vulnerability to future degradation.

On the impaired waters list the 'TMDL Status' is labeled high, medium, or low for a pollutant in Category 5. The categorization for the TMDL Status is defined as follows:

- **High**: A TMDL is currently in development. This could be for any pollutant, but with the current priority framework is most likely addressing TP or TSS. This status is associated with Level 1 Priority in the prioritization framework document.
- **Medium**: These are waters with TP or TSS listings that are in geographic areas identified as vulnerable based on the Healthy Waters Assessment (HWA). These areas have poor predicted ecological health or high phosphorus yields and instream concentrations. Additional waters labeled medium priority are those in the top phosphorus priority areas identified in Wisconsin's Nutrient Strategy. Medium priority is associated with Level 2 Priority in the prioritization framework document.
- **Low**: These are waters with listings that do not fall into High or Medium priority. These listings are likely pollutants other than TP or TSS, but some 5P TP listings may also be in this category if outside the areas identified in the HWA or Nutrient Strategy.

For more information on the prioritization process please refer to the prioritization document.

9-Key Element Plans

Alternatives to a TMDL can be prepared for waters on the 303(d) list. A 9-Key Element Plan covers any plan that includes these nine minimum elements:

A. Identify the causes and sources;
B. Estimate pollutant loading into the watershed and the expected load reductions;
C. Describe management measures that will achieve load reductions and targeted critical areas;
D. Estimate the amounts of technical and financial assistance and the relevant authorities needed to implement the plan;
E. Develop an information/education component;
F. Develop a project schedule;
G. Develop the interim, measurable milestones;
H. Identify indicators to measure progress and make adjustments;
I. Develop a monitoring component.

These nine elements can provide the structure for land and water resource management plans, lake management and protection plans, river protection plans, CWA Section 319-funded watershed plans, and other watershed-based plans. These plans are approved by the EPA. Impairment listings addressed by an EPA approved 9-Key Element plan will be moved to Category 4B (Table 23).

Environmental Accountability Projects (EAPs)

Environmental Accountability Projects or EAPs are another alternative to a TMDL. These are any planned implementation actions on the impaired water that will result in that water meeting WQS. EAPs are commonly used when the source of an impairment and the appropriate management action are readily identifiable. EAP listings are designated when the sources and pathways of pollutants do not require a TMDL analysis to identify management actions. Wisconsin currently has several projects that may have an EAP analysis prepared to address specific pollutants and impairments.

9.0 Public Participation

WDNR recognizes the importance of public involvement in the assessment, restoration and protection of the state's water resources. Public involvement in the development of the state's Impaired Waters List is also required by the CWA. Several opportunities are provided for public comment on the water quality assessments related to the development of the Impaired Waters List and Integrated Report as it is developed, including the following:

- Calls for data as public noticed by WDNR.
- Statewide public informational meetings to discuss the draft list of impaired waters and the WisCALM document used to determine impairments.
- Informal meetings, as resources allow, with interested parties.
- Draft 305(b) report and 303(d) list as public noticed by WDNR with request for comments.
- Supporting assessment documentation provided upon request.
- Public comments must be sent to WDNR during the formal comment period to be considered in the listing decision submittal. However, comments may be sent to WDNR or directly to EPA about WDNR's Integrated Report at any time during the process.

9.1 Requests for Data from the Public

The WDNR provides an opportunity for the public, partners and stakeholders to submit water quality datasets for inclusion in assessment of waters against water quality standards for the Integrated Report of Water Quality. Submittals of quality-assured datasets meeting minimum requirements for assessment will be used in the development of the Integrated Report.

9.2 Submittal of Wisconsin's Integrated Report to U.S. EPA

Wisconsin will provide the EPA with an integrated dataset, a narrative report, associated spatial data files, and a list of updates to the state's 2020 Impaired Waters List on or before April 1, 2020. When this occurs, the WDNR will post the final submittal package on the agency's website (https://dnr.wi.gov/topic/SurfaceWater/assessments.html) for public informational purposes.

10.0 Quick Link Guide

Federal Clean Water Act & EPA Guidance

How US EPA Manages the Quality of its Environmental Data:
https://www.epa.gov/quality

Drinking Water Contaminants- Standards and Regulations:
https://www.epa.gov/dwstandardsregulations?_sm_au_=iVVMN2W4PQ7jM2QN

Beaches Environmental Assessment and Coastal Health Act (BEACH Act):
https://www.epa.gov/beach-tech/about-beach-act

Electronic Code of Federal Regulations, Title 40, Ch. I, Subchapter D, Part 131- Water Quality Standards:
https://www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/Title40/40cfr131_main_02.tpl&_sm_au_=iVVW3452QBmB6LmN

Use Attainability Analysis:
https://www.epa.gov/wqs-tech/use-attainability-analysis-uaa

Wisconsin State Administrative Codes

Chapter NR1.02(7), Trout Stream Classification:
http://docs.legis.wisconsin.gov/code/admin_code/nr/001/1/02

Chapter NR102, Water Quality Standards for Wisconsin Surface Waters:
https://docs.legis.wisconsin.gov/code/admin_code/nr/100/102

Chapter NR 103, Water Quality Standards for Wetlands:
https://docs.legis.wisconsin.gov/code/admin_code/nr/100/103

Chapter NR 104, Uses and Designated Standards:
https://docs.legis.wisconsin.gov/code/admin_code/nr/100/104

Chapter NR 105, Surface Water Quality Criteria and Secondary Values for Toxic Substances:
https://docs.legis.wisconsin.gov/code/admin_code/nr/100/105

Chapter NR 107, Aquatic Plant Management:
https://docs.legis.wisconsin.gov/code/admin_code/nr/100/107

Chapter NR 207, Antidegradation and Antibacksliding:
https://docs.legis.wisconsin.gov/code/admin_code/nr/200/207

Chapter NR 281, Paint and Ink Formulation:
https://docs.legis.wisconsin.gov/code/admin_code/nr/200/281

Monitoring Strategies and Protocols

Wisconsin’s Water Monitoring Strategy 2015 - 2020, June 2015. Wisconsin Department of Natural Resources, Madison, WI:
https://dnr.wi.gov/topic/SurfaceWater/monitoring/strategy/Strategy_2015_2020.pdf

Citizen Lake Monitoring Network:
https://dnr.wi.gov/lakes/CLMN/
http://dnr.wi.gov/lakes/CLMN/manuals/

Citizen Based Stream Monitoring:
https://dnr.wi.gov/topic/surfacewater/monitoring/cbsm.html

Consensus-Based Sediment Quality Guidelines, *WT PUB- 732, 2003* (See Appendix E); https://dnr.wi.gov/files/PDF/pubs/rr/RR088.pdf).

WDNR Topic Pages

Wisconsin's Riverine and Lake Natural Communities:
https://dnr.wi.gov/topic/rivers/naturalcommunities.html

Trout Stream Classifications:
https://dnr.wi.gov/topic/Fishing/trout/streamclassification.html

Water Quality Management Planning:
https://dnr.wi.gov/topic/SurfaceWater/wqmplan/index.html

Total Maximum Daily Loads (TMDLs):
https://dnr.wi.gov/topic/tmdls/

Nine Key Element Watershed Plans:
https://dnr.wi.gov/topic/Nonpoint/9keyElementPlans.html

Wisconsin Beaches:
http://dnr.wi.gov/topic/beaches/

Data Resources and Tools

Surface Water Integrated Monitoring System (SWIMS):
https://dnr.wi.gov/topic/surfacewater/swims/

US Drought Monitor
https://www.drought.gov/drought/data-gallery/us-drought-monitor

Federal Water Quality Exchange Network:
https://www.epa.gov/waterdata/water-quality-data-wqx

Palmer Drought Severity Index:
https://www.ncdc.noaa.gov/temp-and-precip/drought/historical-palmers/

USGS Surface-Water Data for the Nation:
https://waterdata.usgs.gov/nwis/sw

The R Project for Statistical Computing:
http://www.r-project.org/

Wisconsin Beach Health:
www.wibeaches.us

The Impaired Waters Search:

http://dnr.wi.gov/water/impairedSearch.aspx

1980 Trout Book (Wisconsin Trout Streams – Publication 6-3600(80)

Assessment Package Documentation

WisCALM 2018 - E. coli Beach Assessment Parameter Documentation:
http://dnr.wi.gov/water/wsSWIMSDocument.ashx?documentSeqNo=157736003

WisCALM 2018 - Chloride Assessment Parameter Documentation:
http://dnr.wi.gov/water/wsSWIMSDocument.ashx?documentSeqNo=157736016

WisCALM 2018 - Lake Chlorophyll a Assessment Parameter Documentation:
http://dnr.wi.gov/water/wsSWIMSDocument.ashx?documentSeqNo=157736098

WisCALM 2018 - Lake Total Phosphorus Assessment Parameter Documentation:
http://dnr.wi.gov/water/wsSWIMSDocument.ashx?documentSeqNo=157736142

WisCALM 2018 - Large River mIBI R Assessment Parameter Documentation:
http://dnr.wi.gov/water/wsSWIMSDocument.ashx?documentSeqNo=157736160

WisCALM 2018 - River and Stream Total Phosphorus Assessment Parameter Documentation:
http://dnr.wi.gov/water/wsSWIMSDocument.ashx?documentSeqNo=157736173

WisCALM 2018 - Wadeable mIBI Assessment Parameter Documentation:
http://dnr.wi.gov/water/wsSWIMSDocument.ashx?documentSeqNo=157736294

WisCALM 2018 - Lake Trophic State Index (TSI) Assessment Parameter Documentation:
http://dnr.wi.gov/water/wsSWIMSDocument.ashx?documentSeqNo=158820728

WisCALM 2018 - Temperature Assessment Parameter Documentation:
http://dnr.wi.gov/water/wsSWIMSDocument.ashx?documentSeqNo=158820741

WisCALM 2018 - Nonwadeable fIBI Assessment Parameter Documentation:
http://dnr.wi.gov/water/wsSWIMSDocument.ashx?documentSeqNo=159005717

WisCALM 2018 - Wadeable fIBI Assessment Parameter Documentation:
http://dnr.wi.gov/water/wsSWIMSDocument.ashx?documentSeqNo=159005881

Additional Resources

World Health Organization:
http://www.who.int/

Choose Wisely, A Healthy Guide for Eating Fish in Wisconsin (PUB-FH-824 2016):
http://dnr.wi.gov/topic/fishing/consumption/

Technical Fact Sheet- Perfluorooctane Sulfonate (PFOS) and Perfluorooctanoic Acid (PFOA):
https://www.epa.gov/sites/production/files/2017-12/documents/ffrrofactsheet_contaminants_pfos_pfoa_11-20-17_508_0.pdf

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APPENDIX A. Quick Reference Section

Acronyms and Terminology

AL: Aquatic Life Use. Designated use category used to indicate whether waters are appropriate for the protection of fish and other aquatic life.

AMCI: Aquatic Macrophyte Community Index. Multi-metric aquatic plant index which decreases with increasing human disturbance. Used to assess aquatic macrophyte communities in lakes.

AU: Assessment Unit.

BPJ: Best Professional Judgement.

CBSM: Citizen Based Stream Monitoring. Programs that utilize citizen volunteers to collect data to characterize a stream's biology, chemistry, or physical state.

cfu: colony-forming unit. A unit of measurement depicting the number of viable bacterial or fungal cells in a sample. Results are expressed in the form of cfu/mL for liquids and cfu/g for solids.

Chl-*a*: Chlorophyll A (aka CHL). A green pigment, present in all green plants and cyanobacteria, responsible for the absorption of light to provide energy for photosynthesis, measured to assess productivity in lake systems.

CI: Confidence Interval.

Cold: Coldwater. Sub-category in the Aquatic Life Use Designation for streams. Streams classified at "cold" are capable of supporting a cold-water sport fishery, or serving as a spawning area for salmonids and other cold-water fish species.

CWA: Clean Water Act (aka Federal Water Pollution Control Act). Primary United States federal law governing water pollution and quality.

DO: Dissolved Oxygen. The amount of gaseous oxygen dissolved in water, measured in units of milligrams per liter (mg/L).

EAP: Environmental Accountability Project. Any planned implementation actions on an impaired water that will result in that water meeting water quality standards. Environmental Accountability Projects can be utilized as an alternative to TMDLs when the sources and pathways of pollutants do not require a TMDL analysis to identify management actions.

***E. coli: Escherichia coli*.** Coliform bacterium commonly found in the lower intestine of warm-blooded organisms. Some strains of E. coli pose a human health risk and result in conditions such as gastroenteritis, infection, neonatal meningitis, hemorrhagic colitis, and Crohn's disease.

EPA: Environmental Protection Agency. Independent agency of the United States federal government which oversees the maintenance and enforcement of national standards under a variety of environmental laws.

EPT: Ephemeroptera-Plecoptera-Trichoptera. Common stream invertebrates: mayfly, stonefly, caddisfly. One of several metrics used to determine M-IBI for streams.

ERW: Exceptional Resource Water. Wisconsin's designation under state water quality standards to waters with exceptional quality and which may be provided a higher level of protection through various programs and processes.

FCA: Fish Consumption Advisory. Recommendations issued to notify the public that certain species of fish or shellfish caught from a specific water body or type of water body should not be eaten or should be limited for consumption due to chemical contamination.

F-IBI: **Fish Index of biological integrity (Fish IBI).** An Index of Biological Integrity (IBI) is a scientific tool used to identify and classify water pollution problems. An IBI associates anthropogenic influences on a water body with biological activity in the water and is formulated using data developed from biosurveys. In Wisconsin, Fish IBIs are created for each type of natural community in the state's stream system.

g: gram.

HCC: Human Cancer Criteria. Maximum concentrations of substances established to protect humans from an unreasonable incremental risk of cancer resulting from contact with or ingestion of surface waters and from ingestion of aquatic organisms taken from surface waters.

HTC: Human Threshold Criteria. A threshold dosage or concentration of a toxic substance below which it is estimated that no adverse effect or response is likely to occur.

IBI: Index of Biological Integrity. A scientific tool used to identify and classify water pollution problems. Utilizes biological data to analyze anthropogenic influence on a waterbody.

IR: Integrated Report.

Kg: Kilogram.

LAL: Limited Aquatic Life. Sub-category in the Aquatic Life Use Designation

LCL: Lower Confidence Limit.

LFF: Limited Forage Fish. Sub-category in the Aquatic Life Use Designation for streams. Streams designated as "LFF" are capable of supporting small populations of forage fish or tolerant macroinvertebrates that are tolerant of organic pollution.

M-IBI: **Macroinvertebrate Index of biological integrity.** In Wisconsin, the MIBI, or macroinvertebrate Index of biological integrity, was developed specifically to assess Wisconsin's macroinvertebrate community (see also Fish IBI).

Meeting Criteria: When comparing to a water quality criterion this means that the value is not exceeding the criteria. Meeting criteria indicates attainment.

µg/L: micrograms per liter.

NC: Natural Community. A system of categorizing water based on inherent physical, hydrologic, and biological assemblages. Streams and lakes are categorized using an array of "natural community" types.

ng: nanogram.

NPS: Nonpoint Source. Pollution derived from diffuse sources, generally caused by rainfall or snowmelt moving over and through the ground. As the rainfall or snowmelt moves it picks up pollutants and deposits them into lakes, rivers, wetlands, coastal waters, and groundwater.

ORW: Outstanding Resource Water- Wisconsin's designation under state water quality standards to waters with outstanding quality and which may be provided a higher level of protection through various programs and processes.

PCBs: Polychlorinated Biphenyls. A group of man-made organic chemicals commercially produced in the United States from 1929 to 1979. They can have effects on the immune system, reproductive system, nervous system, endocrine system and other health effects, such as increased risk of cancer. They do not readily break down in the environment, so can remain for long periods of time.

PFOS: Perfluorooctane sulfonate. Man-made fluorinated compounds that repel oil and water. PFOS are used in a variety of industrial and consumer products, such as carpet and clothing treatments, and firefighting foams. Toxicological studies on animals indicate potential developmental, reproductive and systemic effects.

PPM: Parts Per Million. A measurement of a substance's concentration in water or soil. One part per million is equivalent to one milligram of a substance per liter of water.

PPT: Parts Per Trillion. A measurement of a substance's concentration in water or soil. One part per trillion is equivalent to one nanogram of a substance per kilogram of water.

PWS: Public Water Supply. This is a surface water used to supply public drinking water. Currently there are only three lakes used for this purpose: Lake Superior, Lake Michigan, and Lake Winnebago.

REC: Recreation Use: Designated use category used to indicate whether waters are appropriate for recreational use. Waters will fail this designated use if a sanitary survey has been completed to show that humans are unlikely to participate in activities requiring full body immersion on the waterbody.

SD: Secchi Depth. A measurement of light transparency in lakes collected using a 20-cm (8-inch) diameter disc painted white and black in alternating quadrants. Depth measurements give a general picture of a lake's water clarity and can help determine if changes occur in a waterbody's clarity over time.

SDWA: Safe Drinking Water Act. Federal law that protects public drinking water supplies throughout the United States. Under the SDWA, EPA sets standards for drinking water quality and with its partners implements various technical and financial programs to ensure drinking water safety.

SU: Standard Unit.

SWIMS: Surface Water Integrated Monitoring System. A WDNR information system that holds chemistry (water, sediment), physical (flow), and biological (macroinvertebrate, aquatic invasive) data**.**

SWIMS ID: Surface Water Integrated Monitoring System (SWIMS) Identification Code. The unique monitoring station identification number for the location where monitoring data was gathered.

TCDD: Tetrachlorodibenzodioxin. In this document it is specifically 2,3,7,8-Tetrachlorodibenzo-P-Dioxin. This is a carcinogenic chemical that was a byproduct of producing certain herbicides. This chemical is also formed from metal production and from burning waste, fossil fuels, and wood. It is a developmental toxicant in animals and is linked to several types of human cancer.

TMDL: Total Maximum Daily Load. A technical report required for impaired waters Clean Water Act. TMDLs identify sources, sinks and impairments associated with the pollutant causing documented impairments.

TP: Total Phosphorus. An analyzed chemical parameter collected in aquatic systems frequently positively correlated with excess productivity and eutrophication in many of Wisconsin's waters.

TSI: Trophic Status Index. Commonly used index of lake productivity published by Carlson in 1977. It provides separate, but relatively equivalent, calculations based on either chlorophyll-*a* concentration or Secchi depth to predict algal biomass in a waterbody.

TSS: Total Suspended Solids. An analyzed physical parameter collected in aquatic systems that is frequently positively correlated with excess productivity, reduced water clarity, reduced dissolved oxygen and degraded biological communities.

WATERS: Waterbody Assessment, Tracking and Electronic Reporting System. A WDNR information system that holds decisions and information regarding the status of rivers, streams, and lakes, as well as
Great Lakes shoreline miles including a variety of use designation, assessment, management uses, and linkages to documents or reports supporting decisions about a waterbody.

WATERS ID: The Waterbody Assessment, Tracking and Electronic Reporting System Identification Code. A unique numerical sequence number assigned by the WATERS system, also known as "Assessment Unit ID code".

WAV: Water Action Volunteer. Statewide program which utilizes individual citizens, environmental groups, students and other volunteer groups to collect data to characterize a stream's biology, chemistry, or physical state.

WBIC: **Water Body Identification Code.** WDNR's unique identification codes assigned to water features in the state. The lines and information allow the user to execute spatial and tabular queries about the data, make maps, and perform flow analysis and network traces.

WDNR: Wisconsin Department of Natural Resources. Wisconsin Department of Natural Resources is an agency of the State of Wisconsin created to preserve, protect, manage, and maintain natural resources.

WHO: World Health Organization. Specialized agency of the United Nations concerned with international public health.

WisCALM: Wisconsin Consolidated Assessment and Listing Methodology. Developed by WDNR, provides guidance on assessment of water quality data against surface water quality standards and for Clean Water Act reporting on surface water quality status and trends. WisCALM is updated for each biennial surface water assessment cycle.

WPDES: Wisconsin Pollutant Discharge Elimination System.

WQS: Water Quality Standards.

WSLH: Wisconsin State Laboratory of Hygiene (aka WSLOH). the state's certified laboratory that provides a wide range of analytical services including toxicology, chemistry, and data sharing.

WWFF: Warmwater Forage Fish. Sub-category in the Aquatic Life Use Designation for streams. Streams designated as “WWFF” are capable of supporting a warm water-dependent forage fishery.

WWSF: Warmwater Sport Fish. Sub-category in the Aquatic Life Use Designation for streams. Streams designated as “WWSF” are capable of supporting a warm water-dependent sport fishery.

Water Quality Criteria & Assessment Quick-Reference Tables

The tables displayed here are meant for quick reference of the most commonly used numeric water quality criteria and do not include detailed assessment methodologies. All numbers outlined in this section are the maximum levels permitted in a waterbody before it is listed as impaired. Please refer to the main body of this document for more information like minimum data requirements and exceedance thresholds; relevant portions are linked in each table's notes.

Lakes: Total Phosphorus & Chlorophyll-*a*

		Total Phosphorus Criteria (µg/L)	**Chlorophyll-*a* Criteria** (AL: µg/L; REC: % days where Chl-*a* > 20 µg/L)	
Stratification[1]	**Lake Natural Community[1]**	**AL[2] & REC[3]**	**AL[2]**	**REC[3]**
Unstratified (Shallow)	Headwater Drainage	40	27	25%
	Lowland Drainage			
	Seepage			
Stratified (Deep)	Headwater Drainage	30	27	5%
	Lowland Drainage			
	Seepage	20		
	Two-Story Fishery	15	10	

1. Natural Community and Stratification definitions can be found in section 4.0 Lake Classification and Assessment Methods.
2. Fish and Aquatic Life Use (AL). Sampling, data selection, and assessment methods for AL TP are found in section 4.5 Lake Impairment Condition Assessment: Aquatic Life (AL) Uses.
3. Recreation Use (REC). Assessment methods for REC TP are the same as AL. Chl-*a* REC assessment methods are found in section 4.6 Lake Impairment Condition Assessment: Recreational Uses.

Rivers & Streams (Aquatic Life Use[4]): Total Phosphorus

Waterbody Type	**Total Phosphorus Criteria (µg/L)[3]**
River[1]	100
Stream	75
Impounded Flowing Water[2]	Criteria of the river or stream associated with the impounded flowing water.

1. A list of waters that have the criteria of 100 µg/L is available in Wisconsin Administrative Code Chapter NR 102.06(3).
2. Impounded Flowing Waters are impoundments that have a water residence time of < 14 days.
3. Assessment protocols can be found in section 5.3 Stream and River Impairment Condition Assessment: Aquatic Life Uses.
4. There currently are no Total Phosphorus criteria for Recreation Use.

All Surface Waters: Chloride

Protection Level	**Criteria (mg/L)[1]**
Chronic Aquatic Toxicity	395
Acute Aquatic Toxicity	757

1. Assessment protocols can be found in section 5.3 Stream and River Impairment Condition Assessment: Aquatic Life Uses and Table 21.

All Surface Waters (Aquatic Life Use): Temperature

Acute Temperature Criteria in Fahrenheit for each month by Water Type[1]						
	Rivers & Streams[2]				Lakes[3]	
Month	Cold	Warm Large	Warm Small	LFF	Northern Lake[4]	Southern Lake[4]
Jan	68	76	76	78	76	77
Feb	68	76	76	79	76	78
Mar	69	76	77	80	76	78
Apr	70	79	79	81	78	80
May	72	82	82	84	81	82
Jun	72	85	84	85	85	86
Jul	73	86	85	86	86	87
Aug	73	86	84	86	86	87
Sep	72	84	82	85	84	85
Oct	70	80	80	83	80	81
Nov	69	77	77	80	78	78
Dec	69	76	76	79	76	77

1. This table is a combination of Acute Temperature Criteria found in Wisc. Admin. Code Chapter NR 102 Tables 2 and 4.
2. River and Stream assessment protocols can be found in Table 20.
3. Lake assessment protocols can be found in Table 10.
4. Northern means North of State Highway 10 and Southern means South of State Highway 10.

Acute Temperature Criteria in Fahrenheit for each month for specific waters[1]					
			Wisconsin River[3]		
Month	Mississippi River	Rock River[2]	Upper	Lower	Lower Fox River
Jan	75	76	76	75	76
Feb	76	76	76	75	76
Mar	76	77	76	77	77
Apr	79	79	78	79	80
May	82	84	82	83	83
Jun	85	85	85	85	85
Jul	86	86	86	86	87
Aug	86	85	85	86	86
Sep	84	84	84	84	85
Oct	81	81	80	80	80
Nov	77	77	77	77	78
Dec	76	76	76	76	76

1. This table was created from Wisc. Admin. Code Chapter NR 102 Tables 2 and 4.
2. Applies to portions of the Rock River downstream of Lake Koshkonong.
3. “Upper” means any part of the Wisconsin River upstream of Petenwell Dam and “Lower” means any part of the Wisconsin River downstream of Petenwell Dam. This does not include impoundments along the Wisconsin River.

All Surface Waters (Aquatic Life Use): Dissolved Oxygen

Waterbody Type	Waterbody Designation	Criteria (mg/L)
Streams, Rivers	Cold Waters	6.0 and 7.0 during spawning season
	Warm Waters	5.0
	Limited Forage Fish	3.0
	Limited Aquatic Life	1.0
Lakes	----	5.0

1. Assessment protocols can be found in section 4.5 Lake Impairment Condition Assessment: Aquatic Life (AL) Use and 5.4 Stream and River Impairment Condition Assessment: Aquatic Life Use.

EPA Five-Part Categorization

The EPA encourages States/Tribes to use a five-category system for classifying all water bodies (or segments) within its boundaries. This classification system is built around designated uses and categorizes waters based on their status in meeting the State's/Tribe's water quality standards. Each waterbody and designated use combination is assigned a condition/reporting category as listed in the table below. More information can be found in section 3.3 Water Quality Condition Categories and Lists.

List	Category/ Subcategory	Description
Healthy Waters	Category 1	**All designated uses are supported**, no use is threatened.
Healthy Waters	Category 2	Available data and/or information indicate that **some, but not all, designated uses are supported**.
	Category 3	There is **insufficient available data** and/or information to make a use support determination.
Restoration Waters	Category 4	Available data and/or information indicate that at least one designated use is not being supported or is threatened, but **a TMDL is not needed**.
Restoration Waters	Category 4a	A State developed TMDL has been approved by EPA or a TMDL has been established by EPA for any segment-pollutant combination.
Restoration Waters	Category 4b	Other required control measures are expected to result in the attainment of an applicable water quality standard in a reasonable period of time.
Restoration Waters	Category 4c	The non-attainment of any applicable water quality standard for the segment is the result of pollution and is not caused by a pollutant.
	Category 5	Available data and/or information indicate that at least one designated use is not being supported or is threatened, and **a TMDL is needed**.

WDNR has further refined Category 5 (waters not meeting water quality standards and a TMDL is needed) waters into subcategories to distinguish among differing types of impaired waters and TMDL priorities.

	Subcategory	Definition
Impaired Waters List	Category 5A	Available information indicates that at least one designated use is not met or is threatened, and/or the anti-degradation policy is not supported, and one or more TMDLs are still needed. This is the **default** category for impaired waters.
Impaired Waters List	Category 5B	Available information indicates that **atmospheric deposition of mercury** has caused the impairment and no other sources have been identified.
Impaired Waters List	Category 5C	Available information indicates that non-attainment of water quality standards may be caused by **naturally occurring or irreversible human-induced conditions**.
Impaired Waters List	Category 5P	Available information indicates that the applicable **total phosphorus** criteria are exceeded; however, biological impairment has not been demonstrated (either because bioassessment shows no impairment or because bioassessment data are not available).
Impaired Waters List	Category 5W	Available information indicates that water quality standards are not met; however, the development of a TMDL for the pollutant of concern is a low priority because the impaired water is included in a watershed area **addressed by at least one** of the following **WDNR-approved watershed plans**: adaptive management plan, adaptive management pilot project, lake management plan, or Clean Water Act Section 319-funded watershed plan (i.e., nine key elements plan).

Listing Combinations

Assessing phosphorus and biology in combination to determine impairment status and pollutant.

	Biological Response Indicators	Overall Assessment Result & EPA Listing Category	Pollutant
Meets TP criteria	None indicate impairment	Not Impaired Category 2	NA
	One or more indicate impairment	Impaired – Biology Only Category 5A	Unknown
Exceeds TP criteria (not an overwhelming exceedance)	One or more indicate impairment	Impaired – TP & Biology Category 5A	TP
	None indicate impairment	Impaired – Exceeds TP but has insufficient or conflicting biological data Category 5P	TP
Exceeds TP criteria by an overwhelming amount	None needed	Impaired – TP Only (i.e. Overwhelming exceedance) Category 5A	TP

Resulting pollutant and/or impairment from an exceedance of each parameter. These are not all the possible parameters assessed, but some of the most common.

Parameter	Pollutant	Aquatic Life Use Impairment	Recreation Use Impairment
Total Phosphorus	Total Phosphorus	Impairment Unknown	Impairment Unknown
Total Phosphorus (Overwhelming Exceedance)	Total Phosphorus	High Phosphorus Levels*	High Phosphorus Levels *
Chlorophyll-*a*	--	Eutrophication	Excess Algal Growth
mIBI	--	Degraded Biological Community	--
fIBI	--	Degraded Biological Community	--
Chloride	Chloride	Chronic Aquatic Toxicity; Acute Aquatic Toxicity	Chronic Aquatic Toxicity; Acute Aquatic Toxicity
Temperature	--	Elevated Water Temperature	Elevated Water Temperature
E. coli	*E. coli*	--	Recreational Use Restrictions

*The term “High Phosphorus Levels” was previously called “Water Quality Use Restrictions” which was used from cycles 2012 – 2018 to indicate an overwhelming exceedance of the total phosphorus criteria.

APPENDIX B. 2018 Impaired Waters Assessment Documentation Form

2020 Impaired Waters Documentation Sheet

Author:	Date Prepared:
Waterbody Name:	Segment:

WADRS ID:	WBIC:	Use i-SWDV (CRTL + Click) to find ID numbers

Choose from the following to indicate what you are recommending:

☐ Proposed new impaired water listing

☐ Proposed changes for water already on 303(d) list (check type of change below) → TMDL ID #: ______

- ☐ Proposed change to existing list (new pollutants, impairments, mileages, etc.)
- ☐ Proposed for de-listing
- ☐ General 303(d) documentation for water already on list

Description of waterbody segment

Start Mile: End Mile: Total miles: Lake Acres:	Detail (describe segment using road crossings, convergence with other waterbodies, etc.):

Use Designation Categories	List use designation & data source for each category.
Current (Existing) Fish & Aquatic Life Use:	
Attainable (Potential) Fish & Aquatic Life Use:	
Designated (Codified) Fish & Aquatic Life Use:	

Is it supporting its FAL Attainable Use? ○ Fully Supporting ○ Not Supporting ○ Not Assessed

Is it supporting its Recreational Use? ○ Fully Supporting ○ Not Supporting ○ Not Assessed

Does a *Specific* Fish Consumption Advisory Exist? ☐ Yes ☐ No ☐ Don't know

If so, what is the specific advisory:

Pollutants & Impairments

Pollutants: (Place an X next to all pollutants that you are recommending for listing or de-listing, or "watch water" monitoring needs.)

☐ Phosphorus	☐ Sediment	☐ Bacteria	☐ PAHs	☐ PCBs
☐ NH_3 (Ammonia)	☐ Thermal	☐ Hg	☐ Creosote	☐ Metals
☐ Unknown	Other Pollutants:			

Impairments: (Place an X next to all impairments that you are recommending for listing, de-listing, or "watch water" monitoring needs.)		
☐ Degraded Habitat	☐ Eutrophication	☐ Temperature
☐ Contaminated Fish Tissue	☐ Chronic Toxicity	☐ Aquatic Toxicity
☐ Unknown	☐ Degraded Biological Community	

Specific causes of impairment: (Describe to the best of your ability what you think is contributing to the impairment.)

Information is based on:

Monitoring data collected on/after January 1, 2009? ☐ YES ☐ NO

If 'NO' then provide justification for using data from the long term record:

Monitoring & Listing Data

Monitoring Study, Date, Results. List water quality exceedances indicating magnitude, duration and frequency (attach additional sheets, if needed).

Monitoring Studies:

Exceedances:

Stations:

Parameters:

Database where data is stored (Fish Database, SWIMS, FishSED, Personal PC):

Narrative on why you are proposing this waterbody to be listed or de-listed?

List and attach any additional reports, updated watershed tables, analyses etc. including use designation survey.

1.
2.
3.
4.

APPENDIX C. Summary of Fish Tissue Criteria for Fish Consumption Advice

Wisconsin fish consumption advisory protocols. (Duplicated from *Wisconsin's Fish Contaminant Monitoring and Advisory Program: 1970-2012* article by Candy S. Shrank in *Wisconsin's Contaminant Monitoring Program* of January 2014).

Contaminant	Population	Concentration Range	Meal Frequency Recommendation
PCBs	All	≤0.05 ppm	Unlimited consumption
		0.05 – 0.22 ppm	1 meal/week or 52 meals/year
		0.22 – 1.0 ppm	1 meal/month or 12 meals/year
		1.0 -1.9 ppm	6 meals/year
		≥ 2 ppm	Do Not Eat
Mercury: General	Sensitive Groups	≤0.05 ppm	Unlimited consumption
		0.05 – 0.22 ppm	1 meal/week or 52 meals/year
		0.22 – 0.95 ppm	1 meal/month or 12 meals/year
		> 0.95 ppm	Do Not Eat
	Others	≤0.16 ppm	Unlimited consumption
		0.16 – 0.65 ppm	1 meal/week or 52 meals/year
		> 0.65 ppm	1 meal/month or 12 meals/year
Mercury: Site-Specific	All	Species-site panfish average > 0.22 ppm (n > 4), max > 0.33 ppm	Sensitive group: 1 meal/month of panfish, Do Not Eat gamefish
		Species-site gamefish average > 0.65 ppm, max > 0.95 ppm	General group: 1 meal/week of panfish, 1 meal/month of gamefish
Dioxin	All	< 10 ppt	No advice given
		> 10 ppt	Do Not Eat
Chlordane	All	≤0.16 ppm	No advice given
		0.16 – 0.65 ppm	1 meal/week or 52 meals/year
		0.66 – 2.82 ppm	1 meal/month or 12 meals/year
		2.83 – 5.62 ppm	6 meals/year
		> 5.62 ppm	Do Not Eat
PFOS	All	< 388 ng/g	Unlimited consumption
		38 – 160 ng/g	1 meal/week or 52 meals/year
		160 – 700 ng/g	1 meal/month or 12 meals/year
		> 700 ng/g	Do Not Eat

[1]**PCB**s - Species-site specific advisories are provided to protect against reproductive health effects and other potential health effects such as immune suppression and cancer. The same advice is given for women, children, and men. The following values were used in deriving the fish tissue criteria for PCBs:

- Health Protection Value of 0.05 µg PCB/kg/day. Average Meal size = 227 g uncooked fish. Consumer = 70 kg adult for others, meal size is assumed proportional to body size). Meal rates defined in the advisory ranging from unrestricted (>225/yr) to none. Skinning/trimming/cooking reduction factor = 50%. The Health Protection Value is from the "Protocol for a Uniform Great Lakes Sport Fish Consumption Advisory. Great Lakes Sport Fish Task Force. September 1993. Since 2000, only specific PCB-based advice is listed for species-sites more stringent than the general statewide advisory.

[2]**Mercury** - Sensitive group includes pregnant women, women of childbearing age, and children under age 15. Others are women beyond childbearing age and men. The HPV for the sensitive group is 0.1 µg/kg/day (EPA RfD) and for others it is 0.3 µg/kg/day (Iraq 1990 RfD). A Protocol for Mercury-based Fish Consumption Advice. Anderson et al., May 2007. Average Meal size = 227 g uncooked fish. Consumer = 70 kg adult (for others, meal size is assumed proportional to body size). Meal rates defined in the advisory ranging from unrestricted (>225/yr) to none. No reduction factor is applied.

- For the statewide general advisory, species were placed in a meal-category considering the distribution of concentrations for each species in the tissue criteria for each meal category, angler harvest, bag and size limitations, and other factors pertinent to consumption.
- In addition to the general advisory, mercury-based special advice is provided for species-sites where higher mercury concentrations have been documented. For special mercury advisories, a number of factors are examined including: maximum and average concentrations for a species in a waterbody or reach, concentration-size relationships, size range of the species expected to be harvested, angler harvest information, and other factors.

[3]Sum of total dioxin equivalence expressed as 2,3,7,8 TCDD based on dioxin and furan congeners and WHO 2005 human health TEFs

[4]Sum of chlordane isomers. Hornshaw 1999 HPV = 0.15 µg/kg/day

[5]MN Rfd (Seacat et al. 2002 Tox Sci 68:249-264) 0.075 µg/kg/day

APPENDIX D. Methodology for Using Field Data to Identify and Correct Wisconsin Stream "Natural Community" Misclassifications (Version 4)

Methodology for Using Field Data to Identify and Correct Wisconsin Stream "Natural Community" Misclassifications

Version 4, May16, 2013

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Summary

All stream and river segments within Wisconsin are classified into one of nine fish-based Natural Communities for bioassessment based on long-term summer maximum water temperature and minimum flow patterns. Temperature and flow values are estimated from landscape-scale, GIS-based, predictive statistical models. These models perform quite well but nonetheless yield inaccurate values for many segments, leading to Natural Community misclassifications. The methodology described here uses actual fish data from bioassessment samples to determine if the predicted Natural Community of a stream segment is appropriate and, if it is not, to assign the segment to the correct Natural Community. The methodology has up to four steps. First, the proportions of the fish catch in different thermal and stream-size guilds are calculated and compared with expectations for the predicted Natural Community. If catches are within the expected ranges, then the predicted Natural Community is retained. If they fall outside these ranges, the second step occurs. In this second step, the proportions of intolerant and tolerant individuals in the fish catch are compared with expected values for the Natural Community. If both proportions are outside expected ranges, then differences between observed and expected thermal and stream-size guilds are likely due to degradation, in which case the predicted Natural Community is retained. If fish catches do not suggest degradation, the third step takes place. In this third step, air temperature and precipitation data are compiled from the nearest weather station. If the mean air temperature in the month before sampling or the total precipitation in the 12 months before sampling were in the top or bottom 10% of values over the last 25 or more years and the nature of the weather was consistent with the mismatch between observed and expected fish catches (e.g., coldwater fish less than expected in an unusually warm period), then weather conditions may have modified fish community characteristics temporarily, and the validity of the predicted Natural Community cannot be determined. A second fish community sample from a non-extreme weather period must be analyzed beginning at step one to determine the appropriate Natural Community for the reach. However, if weather conditions prior to sampling were not extreme or the extreme weather could not explain fish community patterns, the fourth and final step occurs. In this step, best professional judgment is employed to determine if other segment- or sample-specific factors could account for differences between expected and observed proportions of fish thermal and stream-size guilds. If these other factors are judged to be sufficiently important, the predicted Natural Community should be retained. However, if they are judged not sufficiently important, then the Natural Community designation should be changed to match the observed proportions of the fish thermal and stream-size guilds.

Background

Wisconsin streams are highly diverse and contain a wide range of biological communities. This natural diversity must be considered when conducting bioassessments. Presently, inherent variation in fish communities among streams is accounted for through the "Natural Community" classification system. Each of the many stream segments in the state is grouped into one of nine Natural Communities based on estimates of long-term average stream low flow (annual 90% exceedance flow) and summer maximum water temperature (maximum daily mean water temperature) (Table 1), environmental factors that are particularly important in determining stream fish communities. Analyses indicate that stream fish communities from relatively undegraded streams within a particular Natural Community are more similar to each other than they are to fish communities from relatively undegraded streams in other Natural Communities. Each of the Natural Communities has a specific Index of Biotic Integrity (IBI) that is optimized for use in bioassessment.

Wisconsin has over 160,000 discrete stream segments, and relatively few of these have data on flow, water temperature, or fish communities. Thus, segments are initially classified into Natural Communities based on landscape-scale statistical models that predict long-term flows and temperatures from watershed characteristics such as watershed size, surficial and bedrock geology, topography, climate, and land cover. These predictions represent the realistic potential Natural Community of the segment under current land-cover and climate conditions in the absence of significant site-specific human impacts, such as local riparian degradation. In independent validation tests, the models were found to be largely unbiased and to predict the correct Natural Community for about 70-75% of test segments. However, for some test segments the predicted Natural Community was different from the Natural Community that actually occurred.

Errors in Natural Community classification will reduce the accuracy of bioassessment. Misclassified streams will be assessed with the wrong IBI, and their environmental condition may be misjudged. This could lead to some segments being rated as in good condition when in fact they were in poor condition, in which case they would not receive appropriate regulatory and restoration attention. Alternatively, other segments could be scored as poor when they were actually good, and effort could be wasted in trying to restore them unnecessarily. Misclassified segments can only be detected through collection of appropriate field data. However, there are no guidelines on what types of data should be collected, how the data should be interpreted, and how new classifications should be determined. This white paper proposes protocols for using field data to identify misclassified stream segments and to determine their appropriate Natural Community classification.

The Issue

Since the statistical models of flow and water temperature misclassify some stream segments into the wrong Natural Communities, when and how should field data be used to assign individual stream segments into different and more appropriate Natural Communities?

Proposed Methodology

Detection:

A potentially misclassified stream segment can be detected either during a field survey or via a review of existing field data. Conceptually, misclassification could be indicated by discrepancies between predicted and actual measurements of flow, water temperature, or the fish community. However, for several reasons, the most reliable and cost-effective indicator of misclassification will be fish community data. The Natural Community classification is based on predicted average summer maximum temperature and annual low flow over a 20-year period. Neither value can be measured directly without an expensive long-term monitoring program, impractical in nearly all cases. Short-term approximations are possible, but they require multiple site visits, and the estimated values are highly variable and particularly sensitive to short-term variations in weather (e.g., droughts and floods, heat-waves and cold-spells). Fish data, on the other hand, require only a single site visit, utilize the same information as the actual bioassessment, and are relatively more stable and less influenced by weather extremes than water temperature and stream flow measures.

Fish data can provide insight into both the thermal and flow (stream-size) attributes of stream segments. In the absence of major environmental degradation, each Natural Community has a characteristic fish community, with expected ranges of coldwater, transitional, and warmwater individuals (Table 2), and small-stream, medium-stream, and large-river individuals (Table 3). The observed relative abundances of fish thermal and stream-size guilds can indicate whether the designated Natural Community is correct. However, not all mismatches between expected and observed fish community characteristics represent a Natural Community misclassification. Often, fish communities have been modified by environmental degradation of the stream segment. Or fish may display temporary distribution and abundance shifts in response to unusual weather conditions. The predicted Natural Community classification represents the potential of the segment in the absence of major site-specific environmental impacts and under average climate conditions, whereas the observed conditions will incorporate the effects of weather extremes and local human activities in and along the stream. The segment may have fish community values outside the range of its predicted Natural Community because it has poor environmental quality or because of atypical weather, not because it has been misclassified. Thus, when predicted and observed values do not agree, the challenge is determining whether this disagreement occurs because the predictions are wrong or because the predictions are correct but the segment has been environmentally degraded or has recently experienced extreme precipitation or air temperatures.

It is important to note that the process of determining whether the designated Natural Community of a stream segment is accurate is separate and different from the process of bioassessment of that segment with the IBI, even though both processes use the same fish catch data. The Natural Community process takes place first and must be completed before the IBI process can begin. The IBI process relies on an accurate Natural Community classification to determine which IBI should be employed. The fish metrics used to determine the appropriate Natural Community are largely different from those used in the IBI bioassessment; only the percentage tolerant fish metric occurs in both. The determination of segment degradation in the Natural Community process is not a substitute for bioassessment, and the ultimate determination of the ecological health of the segment should rely on the IBI analysis.

Data Interpretation:
Two types of data are necessary to assess the accuracy of the designated Natural Community classification of a stream segment: fish community data and weather and climate information.

Fish Community: Standard fish bioassessment procedures can be used to determine the relative abundances of fish individuals within each of the thermal and stream-size guilds at a stream segment. These abundances can then be compared with expectations for the predicted Natural Community from Tables 2 and 3. If the observed abundances differ from the expected abundances (e.g., the sample yields a high percentage of coldwater individuals but the expectation is that coldwater individuals should be rare), then the segment may be misclassified. However, before a final determination can be made, the environmental quality of the segments and the recent weather it has experienced need to be considered. Environmental quality can be inferred from the fish community data. Environmental degradation tends to eliminate intolerant species and elevate the relative abundance of tolerant individuals. If a site has both no intolerant species and more tolerant individuals than expected (Table 4), then the fish community may be reflecting human impacts rather than an inappropriate Natural Community classification. If abundances of either intolerant or tolerant individuals or both are within appropriate ranges, then weather and climate information needs to be examined.

Weather and Climate: Weather extremes complicate determination of the appropriate Natural Community because fish may shift locations and increase or decrease in abundance in response to unusual air temperatures and amounts of precipitation. Local data on recent weather and long-term climate patterns are available statewide from weather stations. Long-term climate information provides the average monthly air temperature and total annual precipitation for a stream segment, whereas recent weather reveals the actual air temperatures and precipitation the segment experienced just before the fish community was sampled. If air temperatures during the month before sampling or total precipitation during the 12 months previous to sampling are not extreme – not in the top or bottom 10% of values over the last 25 or more years – then unusual weather probably does not explain differences between observed and expected fish relative abundances, and a Natural Community misclassification is likely. Conversely, if air temperatures or precipitation are extreme, then unusual weather may account for the differences, in which case the direction of those differences becomes important. Differences in fish communities consistent with the weather extremes, such as more coldwater and large-river species than expected during unusually cold and wet periods or fewer coldwater and large-river species during unusually hot and dry periods, could merely reflect atypical weather and not indicate a Natural Community misclassification. The fish community would need to be re-sampled when air temperatures and precipitation were closer to average to determine the appropriate classification. However, differences inconsistent with weather extremes, such as fewer coldwater and large-river species than expected during unusually cold and wet periods or more coldwater and large-river species during unusually hot and dry periods, would be evidence that the segment was misclassified.

Determining the Appropriate Natural Community:

The use of field data to determine the appropriate Natural Community classification of a stream segment involves a process of answering up to four questions:

Question 1: **Does the actual catch of fish in the three thermal and three stream-size guilds match the expectations for the designated Natural Community of the segment?** Fish data should be collected from the study segment following standardized bioassessment procedures. All fish collected (excluding those that appeared to have been stocked or released/escaped from a bait bucket or ornamental pond or tank within the last 90 days) should be classified into the appropriate thermal and stream-size guilds based on Table 5. Percentages of the fish catch in each of the three thermal guilds (based on numbers of individuals) should be compared with the expected range for that thermal guild from Table 2 for the designated Natural Community of the segment. If all the observed percentages are within the expected ranges, then the designated thermal Natural Community is probably appropriate and should be retained. However, if one or more of the observed thermal guild percentages falls outside the expected range then the designated thermal Natural Community may be inappropriate and the analysis should continue to Question 2. Similarly, percentages of the fish catch in each of the three stream-size guilds (based on numbers of individuals) should be compared with the expected range for that stream-size guild from Table 3 for the designated Natural Community of the segment. If all the observed percentages are within the expected ranges, then the designated Natural Community is probably appropriate and should be retained. However, if one or more of the observed stream-size guild percentages falls outside the expected range then the designated stream-size Natural Community may be inappropriate and the analysis should continue to Question 2.

Question 2: **Can environmental degradation at the segment explain differences between observed and expected percentages for the thermal or stream-size guilds?** Fish should be classified into the appropriate tolerance guilds based on Table 5 and then the percentages of the fish catch in the intolerant and tolerant tolerance guilds (based on numbers of individuals) should be compared with the expected range from Table 4 for the designated Natural Community of the segment. If intolerant species are absent <u>and</u> the percentage of tolerant individuals is higher than expected (both must be true) then the segment is likely degraded, and deviations from expected ranges for the thermal or stream-size guilds could have been caused by the degradation rather than a Natural Community misclassification. In such a case the designated Natural Community is probably appropriate and should be retained. However, if intolerant species are present or the percentage of tolerant species is within the expected range, or both, then the segment is unlikely to be degraded, and therefore degradation cannot explain deviations from expected ranges for the thermal or stream-size guilds. In that case, the analysis should continue to Question 3.

Question 3: **Can recent weather extremes at the segment explain differences between observed and expected percentages for the thermal or stream-size guilds?** Long-term ($\geq$ 25 year period) data on mean air temperatures for the month before sampling and total annual precipitation for the 12 months before sampling should be obtained from the weather station nearest to the segment, and the mean monthly air temperature for the month prior to the sampling and the total precipitation for the 12 months prior to sampling should be calculated. Values for monthly mean air temperature and total annual precipitation should be compared with the values from previous years to determine if weather conditions just before sampling were extreme for that segment, that is, in the bottom 10% or top 90% of values across all years. If the weather was not extreme, then the analysis should continue to Question 4. If the weather was extreme, then the nature of the weather extremes should be examined. Unusually cold conditions could lead to relatively more coldwater or transitional individuals and fewer warmwater individuals but would be unlikely to lead to fewer coldwater or transitional individuals and more warmwater individuals. Unusually wet conditions could lead to relatively more medium-stream or large-river individuals and fewer small-stream individuals but would be unlikely to lead to fewer medium-stream or large-river individuals and more small-stream individuals. The opposite expectations would be likely for unusually warm or dry conditions. If extreme weather conditions just before sampling were consistent with differences between observed and expected fish communities, then the recent weather conditions might account for these differences, and fish sampling would need to be repeated during a non-extreme year and the resulting data analyzed beginning with Question 1 in order to determine if the designated Natural Community was appropriate. However if the extreme weather conditions just prior to sampling were inconsistent with the differences between observed and expected fish communities, then recent weather conditions would be unlikely to account for the differences, and the analysis should continue to Question 4.

Question 4: **Considering other available information on fish, weather, and segment characteristics and location, and employing Best Professional Judgment (BPJ), is there sufficient justification for changing the Natural Community classification of the segment?** The determination of whether to change the Natural Community classification cannot be a completely automated process and must consider other relevant information, sometimes qualitative or anecdotal in nature, which could influence which fish were actually captured from a stream segment. Even if the answers to the previous three questions support a change in the Natural Community designation for a segment, a biologist familiar with the segment and more generally the streams and rivers of the region should review all available information and use BPJ to decide whether a change is actually warranted. Consideration should be given to factors besides degradation and unusual weather that might account for differences between observed and expected fish abundances. These could include factors that call into question the representativeness of the fish sample (e.g., difficult sampling conditions because of high water or bad weather, or equipment problems that reduced effectiveness) and suggest that a new sample should be collected and analyzed, and factors related to unique characteristics of the segment that might account for differences between observed and expected fish percentages (e.g., a cool-cold headwater segment that emptied directly into a large warmwater river might have more warmwater and large-river fish than expected because of strays from the river) and suggest that the existing Natural Community classification should be retained.

However, if the sample thought to be representative, and the segment is judged to not have unique characteristics, then a new Natural Community classification should be assigned based on the observed relative abundances of fish thermal and stream-size guilds using the criteria in Tables 2 and 3. The new classification, along with supporting data and analyses, should be documented in a standardized format (See Appendix) and made available for incorporation into the statewide stream Natural Community database.

Example Calculation:
Little Scarboro Creek, Kewaunee County; October 29, 2008; 100 m backpack sample
Designated Natural Community – Cool-Cold Transition Headwater

<u>Fish catch</u>

American Brook Lamprey N=2 (Transitional, Medium-Stream, Intolerant)
Western Blacknose Dace N=1 (Transitional, Small-Steam, Tolerant)
Creek Chub N=25 (Transitional, Small-Stream, Tolerant)
Central Mudminnow N =1 (Transitional, Small-Stream, Tolerant)
Coho Salmon N=7 (Coldwater, Medium-Stream, Intermediate)
Rainbow Trout N=15 (Coldwater, Medium-Stream, Intermediate)
Brook Trout N = 61 (Coldwater, Small-Stream, Intolerant)
Mottled Sculpin N=46 (Coldwater, Small-Stream, Intolerant)
Total Fish = 158 individuals

Observed Guild Percentages
Thermal: Coldwater = 82% (129/158); Transitional = 18% (29/158); Warmwater = 0% (0/158)
Stream-Size: Small-Stream = 85% (135/158); Medium-Stream =15% (23/158); Large-River = 0% (0/158)
Tolerance: Intolerant = 69% (109/158); Intermediate = 14% (22/158); Tolerant = 18% (27/158)

Expected Guild Percentages for Cool-Cold Transitional Headwater (from Tables 2-4)
Thermal: Coldwater 0-75%; Transitional 25-100%; Warmwater 0-25%
Stream-Size: Small-Stream 50-100%; Medium-Stream 0-50%; Large-River 0-10%
Tolerance: Intolerant – > 0% (i.e., Present); Intermediate – Not applicable; Tolerant 0-75%
Question 1: Does the actual percentages of fish in the three thermal and three stream-size guilds match the expectations for the designated Natural Community of the segment?
Thermal: Higher percentage of coldwater individuals than expected (0-75% < **82%** [observed values in bold]), lower percentage of transitional individuals than expected (**18%** < 25-100%), within expected range of warmwater individuals (0% ≤ **0%** < 25%). **Conclusion: Possible Thermal Natural Community Misclassification (Cool-Cold Transition expectations not met; observed fish match expectations for Coldwater).**
Stream-Size: Percentages of small-stream (50% < **85%** < 100%); medium-stream (0% < **15%** < 50%), and large-river individuals (0% ≤ **0%** < 10%) all within expectations. **Conclusion: Stream-Size Natural Community Appropriate (Headwater).**

Question 2: Can environmental degradation at the segment explain differences between observed and expected percentages for the thermal or stream-size guilds?
Intolerant individuals are present (0% < **69%**) and the percentage of tolerant individuals (0% < 1**8%** < 75%) are within expectations for a non-degraded cool-cold transition headwater stream.
Conclusion: Segment likely NOT degraded.

Question 3: Can recent weather extremes at the segment explain differences between observed and expected percentages for the thermal or stream-size guilds?
Data from the nearest weather station at Kewaunee (station 474195) from 1977-2008:
Mean September Air Temperature range: 55.2 F (1993) – 64.5 F (1998); 2008 @ 60.8 F. Of the 30 years with data, 2008 had the 19^{th} coldest and 11^{th} warmest mean air temperature for the month of September. The 10^{th} percentile mean September air temperature was 57.1 F and the 90^{th} was 63.6 F. Therefore, 2008 @ 60.8 F was within the 10^{th} to 90^{th} percentile range.
Total Annual (October – September) Precipitation range: 19.94 inches (1994-1996) – 42.12 inches (1985-1986); October 2007- September 2008 @ 28.07 inches; Of the 21 years with complete precipitation data, 2007-2008 was the 7^{th} driest and 14^{th} wettest year. The 10^{th} percentile total annual precipitation was 24.80 inches and the 90^{th} was 38.84 inches. Therefore, 2007-2008 @ 28.07 inches was within the 10^{th} to 90^{th} percentile range.
Conclusion: September 2008 was NOT an unusually hot or cold month and October 2007-September 2008 was NOT an unusually wet or dry period. Therefore, there was no extreme weather just before sampling.

Question 4: Considering other available information on fish, weather, and segment characteristics and location, and employing Best Professional Judgment (BPJ), is there sufficient justification for changing the Natural Community classification of the segment?
Observed thermal guild percentages were distinctly different from expectations and outside the realm of normal sampling variation. No flow, weather, or equipment issues affected sampling effectiveness. The segment was not close to a very different Natural Community where strays would have potentially influenced fish thermal guild percentages. In 2008, the fish community sample was collected outside of the standard May-September sampling time frame. However, fish collections in 2007, 2009, and 2010 yielded similar results to 2008, indicating that the discrepancies between observations and expectations were real and not merely the result of a sampling date later in the fall. There were no unusual features of the sampling or the segment or of the 2007-08 weather patterns that could explain the discrepancies between expected and observed fish thermal-guild percentages.
Conclusion: Based on existing data and my knowledge of Little Scarboro Creek and similar nearby streams, a thermal Natural Community misclassification of the segment seems likely.

Overall Conclusion: Change Thermal Classification from Cool-Cold Transition to Coldwater. Retain Stream-Size Classification as Headwater
(Note: the Coldwater Natural Community does not have separate Headwater and Mainstem Stream-Size classifications, so the overall new Natural Community becomes **Coldwater**)

Table 1 – Modeled water temperature and flow criteria used to predict Natural Communities in healthy Wisconsin streams and the primary index of biotic integrity (IBI) for bioassessment associated with each Natural Community.

Natural Community	Long-Term Average Maximum Daily Mean Water Temperature (˚F)	Long-Term Average Annual 90% Exceedance Flow (ft^3/s)	Primary Index of Biotic Integrity
Macroinvertebrate	Any	< 0.03	Macroinvertebrate
Coldwater	< 69.3	0.03-150	Coldwater Fish
Cool-Cold Headwater	69.3 - 72.5	0.03-3.0	Small-Stream (Intermittent) Fish
Cool-Cold Mainstem	69.3 - 72.5	3.0-150	Cool-Cold Transition (Coolwater) Fish
Cool-Warm Headwater	72.6 - 76.3	0.03 - 3.0	Small-Stream (Intermittent) Fish
Cool-Warm Mainstem	72.6 - 76.3	3.0-150	Cool-Warm Transition (Coolwater) Fish
Warm Headwater	> 76.3	0.03 - 3.0	Small-Stream (Intermittent) Fish
Warm Mainstem	> 76.3	3.0 - 110.0	Warmwater Fish
Nonwadeable Warm River	> 76.3	> 150.0	Large River Fish

Table 2 – Fish thermal guild expectations (percentage of total individuals collected) for Natural Communities in non-degraded Wisconsin streams. See Table 5 for fish species thermal guild assignments. Species that belong to the “lake” stream-size guild in Table 5 should be excluded from calculations. At least 25 total fish must be collected from the stream segment to apply these criteria. Fish that are known or thought to have been stocked (including bait bucket and ornamental pond/tank escapees/releases) within 90 days of the sampling should be excluded from all calculations.

Natural Community	Coldwater Individuals	Transitional Individuals	Warmwater Individuals
Macroinvertebrate	Not applicable	Not applicable	Not applicable
Coldwater	25-100%	0-75%	0-5%
Cool-Cold Headwater	0-75%	25-100%	0-25%
Cool-Cold Mainstem	0-75%	25-100%	0-25%
Cool-Warm Headwater	0-25%	25-100%	0-75%
Cool-Warm Mainstem	0-25%	25-100%	0-75%
Warm Headwater	0-5%	0-25%	75-100%
Warm Mainstem	0-5%	0-25%	75-100%
Nonwadeable Warm River	0-5%	0-25%	75-100%

Table 3 – Fish stream-size guild expectations (percentage of total individuals collected) for Natural Communities in non-degraded Wisconsin streams. See Table 5 for fish stream-size guild assignments. Species that belong to the lake guild should be excluded from calculations. At least 25 total fish must be collected from the segment to apply any of the percentage criteria. Fish that are known or thought to have been stocked (including bait bucket and ornamental pond/tank escapees/releases) within 90 days of the sampling should be excluded from calculations.

Natural Community	Small-Stream Individuals	Medium-Stream Individuals	Large-River Individuals
Macroinvertebrate	Total catch of fish (all size guilds combined) less than 25 individuals in at least 100 m wetted stream length sampled Absent		
Coldwater	0-100%	0-100%	0-100%
Cool-Cold Headwater	50-100%	0-50%	0-10%
Cool-Cold Mainstem	0-50%	50-100%	0-50%
Cool-Warm Headwater	50-100%	0-50%	0-10%
Cool-Warm Mainstem	0-50%	50-100%	0-50%
Warm Headwater	50-100%	0-50%	0-10%
Warm Mainstem	0-50%	50-100%	0-50%
Nonwadeable Warm River	0-10%	0-25%	75-100%

Table 4 – Fish tolerance guild expectations (percentage of total individuals collected) for Natural Communities in non-degraded Wisconsin streams. See Table 5 for fish species tolerance guild assignments. Species that belong to the "lake" stream-size guild in Table 5 should be excluded from calculations. Fish that are known or thought to have been stocked (including bait bucket or ornamental pond/tank escapees/releases) within 90 days of the sampling should be excluded from all calculations. Note: For purposes of Natural Community verification, the percentage of intermediate individuals is not used to determine degradation status.

Natural Community	Intolerant Individuals	Intermediate Individuals	Tolerant Individuals
Macroinvertebrate	Not applicable	Not applicable	Not applicable
Coldwater	> 0% (i.e., Present)	Not applicable	0-25%
Cool-Cold Headwater	> 0% (i.e., Present)	Not applicable	0-75%
Cool-Cold Mainstem	> 0% (i.e., Present)	Not applicable	0-70%
Cool-Warm Headwater	> 0% (i.e., Present)	Not applicable	0-75%
Cool-Warm Mainstem	> 0% (i.e., Present)	Not applicable	0-60%
Warm Headwater	> 0% (i.e., Present)	Not applicable	0-75%
Warm Mainstem	> 0% (i.e., Present)	Not applicable	0-50%
Nonwadeable Warm River	> 0% (i.e., Present)	Not applicable	0-15%

Table 5 – Thermal, stream-size, and tolerance guilds of Wisconsin fishes. Lake indicates a species that primarily inhabits lakes in Wisconsin. Such species may occasionally be collected in the lower reaches of tributaries, especially during their spawning seasons, but they are not regular stream or river inhabitants and should be excluding from thermal-, stream-size-, and tolerance-guild percentage calculations.

Common Name	Scientific Name	Thermal	Stream-Size	Tolerance
LAMPREYS	PETROMYZONTIDAE			
Chestnut Lamprey	*Ichthyomyzon castaneus*	Warmwater	Large	Intolerant
Northern Brook Lamprey	*Ichthyomyzon fossor*	Transitional	Medium	Intolerant
Southern Brook Lamprey	*Ichthyomyzon gagei*	Transitional	Medium	Intolerant
Silver Lamprey	*Ichthyomyzon unicuspis*	Warmwater	Large	Intolerant
American Brook Lamprey	*Lampetra appendix*	Transitional	Medium	Intolerant
Sea Lamprey	*Petromyzon marinus*	Transitional	Medium	Intolerant
STURGEONS	ACIPENSERIDAE			
Lake Sturgeon	*Acipenser fulvescens*	Transitional	Large	Intermediate
Shovelnose Sturgeon	*Scaphirhynchus platorynchus*	Warmwater	Large	Intermediate
PADDLEFISHES	POLYODONTIDAE			
Paddlefish	*Polyodon spathula*	Warmwater	Large	Intermediate
GARS	LEPISOSTEIDAE			
Longnose Gar	*Lepisosteus osseus*	Warmwater	Large	Intermediate
Shortnose Gar	*Lepisosteus platostomus*	Warmwater	Large	Intermediate
BOWFINS	AMIIDAE			
Bowfin	*Amia calva*	Warmwater	Large	Intermediate
MOONEYES	HIODONTIDAE			
Goldeye	*Hiodon alosoides*	Warmwater	Large	Intermediate
Mooneye	*Hiodon tergisus*	Warmwater	Large	Intermediate
FRESHWATER EELS	ANGUILLIDAE			
American Eel	*Anguilla rostrata*	Warmwater	Large	Intermediate
HERRINGS	CLUPEIDAE			
Skipjack Herring	*Alosa chrysochloris*	Warmwater	Large	Intermediate
Alewife	*Alosa pseudoharengus*	Transitional	Lake	Intermediate
Gizzard Shad	*Dorosoma cepedianum*	Warmwater	Large	Intermediate
MINNOWS	CYPRINIDAE			
Central Stoneroller	*Campostoma anomalum*	Warmwater	Small	Intermediate
Largescale Stoneroller	*Campostoma oligolepis*	Warmwater	Small	Intermediate
Goldfish	*Carassius auratus*	Warmwater	Medium	Tolerant
Redside Dace	*Clinostomus elongatus*	Transitional	Small	Intolerant
Lake Chub	*Couesius plumbeus*	Transitional	Lake	Intermediate
Spotfin Shiner	*Cyprinella spiloptera*	Warmwater	Large	Intermediate
Common Carp	*Cyprinus carpio*	Warmwater	Large	Tolerant
Gravel Chub	*Erimystax x-punctatus*	Warmwater	Large	Intolerant
Brassy Minnow	*Hybognathus hankinsoni*	Transitional	Small	Intermediate
Mississippi Silvery Minnow	*Hybognathus nuchalis*	Warmwater	Large	Intolerant
Pallid Shiner	*Hybopsis amnis*	Warmwater	Large	Intolerant
Striped Shiner	*Luxilus chrysocephalus*	Warmwater	Medium	Intermediate
Common Shiner	*Luxilus cornutus*	Warmwater	Medium	Intermediate
Redfin Shiner	*Lythrurus umbratilis*	Warmwater	Medium	Intermediate
Shoal (Speckled) Chub	*Macrhybopsis hyostoma*	Warmwater	Large	Intolerant
Silver Chub	*Macrhybopsis storeriana*	Warmwater	Large	Intermediate
Pearl Dace	*Margariscus margarita*	Transitional	Small	Intermediate
Hornyhead Chub	*Nocomis biguttatus*	Warmwater	Medium	Intermediate
Golden Shiner	*Notemigonus crysoleucas*	Warmwater	Medium	Tolerant
Pugnose Shiner	*Notropis anogenus*	Transitional	Medium	Intolerant
Emerald Shiner	*Notropis atherinoides*	Warmwater	Large	Intermediate

River Shiner	*Notropis blennius*	Warmwater	Large	Intermediate
Ghost Shiner	*Notropis buchanani*	Warmwater	Large	Intolerant
Ironcolor Shiner	*Notropis chalybaeus*	Warmwater	Medium	Intermediate
Bigmouth Shiner	*Notropis dorsalis*	Warmwater	Medium	Intermediate
Blackchin Shiner	*Notropis heterodon*	Transitional	Medium	Intolerant
Blacknose Shiner	*Notropis heterolepis*	Transitional	Medium	Intolerant
Spottail Shiner	*Notropis hudsonius*	Warmwater	Large	Intolerant
Ozark Minnow	*Notropis nubilus*	Warmwater	Medium	Intolerant
Carmine Shiner	*Notropis percobromus*	Warmwater	Medium	Intolerant
Rosyface Shiner	*Notropis rubellus*	Warmwater	Medium	Intolerant
Sand Shiner	*Notropis stramineus*	Warmwater	Large	Intermediate
Weed Shiner	*Notropis texanus*	Warmwater	Large	Intolerant
Mimic Shiner	*Notropis volucellus*	Warmwater	Large	Intermediate
Channel Shiner	*Notropis wickliffi*	Warmwater	Large	Intermediate
Pugnose Minnow	*Opsopoeodus emiliae*	Warmwater	Large	Intermediate
Suckermouth Minnow	*Phenacobius mirabilis*	Warmwater	Medium	Intermediate
Northern Redbelly Dace	*Phoxinus eos*	Transitional	Small	Intermediate
Southern Redbelly Dace	*Phoxinus erythrogaster*	Warmwater	Small	Intermediate
Finescale Dace	*Phoxinus neogaeus*	Transitional	Small	Intermediate
Bluntnose Minnow	*Pimephales notatus*	Warmwater	Medium	Tolerant
Fathead Minnow	*Pimephales promelas*	Warmwater	Small	Tolerant
Bullhead Minnow	*Pimephales vigilax*	Warmwater	Large	Intermediate
Longnose Dace	*Rhinichthys cataractae*	Transitional	Medium	Intermediate
Western Blacknose Dace	*Rhinichthys obtusus*	Transitional	Small	Tolerant
Creek Chub	*Semotilus atromaculatus*	Transitional	Small	Tolerant
SUCKERS	CATOSTOMIDAE			
River Carpsucker	*Carpiodes carpio*	Warmwater	Large	Intermediate
Quillback	*Carpiodes cyprinus*	Warmwater	Large	Intermediate
Highfin Carpsucker	*Carpiodes velifer*	Warmwater	Large	Intolerant
Longnose Sucker	*Catostomus*	Coldwater	Medium	Intolerant
White Sucker	*Catostomus commersonii*	Transitional	Medium	Tolerant
Blue Sucker	*Cycleptus elongatus*	Warmwater	Large	Intolerant
Creek Chubsucker	*Erimyzon oblongus*	Warmwater	Medium	Intermediate
Lake Chubsucker	*Erimyzon sucetta*	Warmwater	Medium	Intermediate
Northern Hog Sucker	*Hypentelium nigricans*	Transitional	Medium	Intolerant
Smallmouth Buffalo	*Ictiobus bubalus*	Warmwater	Large	Intermediate
Bigmouth Buffalo	*Ictiobus cyprinellus*	Warmwater	Large	Intermediate
Black Buffalo	*Ictiobus niger*	Warmwater	Large	Intolerant
Spotted Sucker	*Minytrema melanops*	Warmwater	Large	Intolerant
Silver Redhorse	*Moxostoma anisurum*	Warmwater	Large	Intermediate
River Redhorse	*Moxostoma carinatum*	Warmwater	Large	Intermediate
Black Redhorse	*Moxostoma duquesnei*	Warmwater	Large	Intolerant
Golden Redhorse	*Moxostoma erythrurum*	Warmwater	Medium	Intermediate
Shorthead Redhorse	*Moxostoma macrolepidotum*	Warmwater	Large	Intermediate
Greater Redhorse	*Moxostoma valenciennesi*	Warmwater	Large	Intolerant
BULLHEAD CATFISHES	ICTALURIDAE			
Black Bullhead	*Ameiurus melas*	Warmwater	Medium	Tolerant
Yellow Bullhead	*Ameiurus natalis*	Warmwater	Medium	Tolerant
Brown Bullhead	*Ameiurus nebulosus*	Warmwater	Large	Intermediate
Channel Catfish	*Ictalurus punctatus*	Warmwater	Large	Intermediate
Slender Madtom	*Noturus exilis*	Warmwater	Medium	Intolerant
Stonecat	*Noturus flavus*	Warmwater	Medium	Intermediate
Tadpole Madtom	*Noturus gyrinus*	Warmwater	Large	Intermediate
Flathead Catfish	*Pylodictis olivaris*	Warmwater	Large	Intermediate
PIKES	ESOCIDAE			
Grass Pickerel	*Esox americanus vermiculatus*	Warmwater	Medium	Intermediate
Northern Pike	*Esox lucius*	Transitional	Small	Intermediate
Muskellunge	*Esox masquinongy*	Transitional	Large	Intolerant
MUDMINNOWS	UMBRIDAE			
Central Mudminnow	*Umbra limi*	Transitional	Small	Tolerant
SMELTS	OSMERIDAE			

Rainbow Smelt	*Osmerus mordax*	Coldwater	Lake	Intermediate
TROUTS	SALMONIDAE			
Cisco/Lake Herring	*Coregonus artedi*	Coldwater	Lake	Intolerant
Lake Whitefish	*Coregonus clupeaformis*	Coldwater	Lake	Unclassified
Bloater	*Coregonus hoyi*	Coldwater	Lake	Unclassified
Deepwater Cisco	*Coregonus johannae*	Coldwater	Lake	Unclassified
Kiyi	*Coregonus kiyi*	Coldwater	Lake	Unclassified
Blackfin Cisco	*Coregonus nigripinnis*	Coldwater	Lake	Unclassified
Shortnose Cisco	*Coregonus reighardi*	Coldwater	Lake	Unclassified
Shortjaw Cisco	*Coregonus zenithicus*	Coldwater	Lake	Intolerant
Pink Salmon	*Oncorhynchus gorbuscha*	Coldwater	Medium	Intermediate
Coho Salmon	*Oncorhynchus kisutch*	Coldwater	Medium	Intermediate
Rainbow Trout	*Oncorhynchus mykiss*	Coldwater	Medium	Intermediate
Kokanee/Sockeye Salmon	*Oncorhynchus nerka*	Coldwater	Lake	Unclassified
Chinook Salmon	*Oncorhynchus tshawytscha*	Coldwater	Medium	Intermediate
Pygmy Whitefish	*Prosopium coulteri*	Coldwater	Lake	Unclassified
Round Whitefish	*Prosopium cylindraceum*	Coldwater	Lake	Unclassified
Brown Trout	*Salmo trutta*	Coldwater	Medium	Intermediate
Brook Trout	*Salvelinus fontinalis*	Coldwater	Small	Intolerant
Lake Trout	*Salvelinus namaycush*	Coldwater	Lake	Intolerant
TROUT-PERCHES	PERCOPSIDAE			
Trout-perch	*Percopsis omiscomaycus*	Transitional	Large	Intermediate
PIRATE PERCHES	APHREDODERIDAE			
Pirate Perch	*Aphredoderus sayanus*	Warmwater	Medium	Intermediate
CODFISHES	GADIDAE			
Burbot	*Lota lota*	Transitional	Large	Intermediate
TOPMINNOWS	FUNDULIDAE			
Banded Killifish	*Fundulus diaphanus*	Warmwater	Medium	Intermediate
Starhead Topminnow	*Fundulus dispar*	Warmwater	Large	Intermediate
Blackstripe Topminnow	*Fundulus notatus*	Warmwater	Large	Intermediate
LIVEBEARERS	POECILIIDAE			
Western mosquitofish	*Gambusia affinis*	Warmwater	Medium	Tolerant
NEW WORLD SILVERSIDES	ATHERINOPSIDAE			
Brook Silverside	*Labidesthes sicculus*	Warmwater	Large	Intermediate
STICKLEBACKS	GASTEROSTEIDAE			
Brook Stickleback	*Culaea inconstans*	Transitional	Small	Tolerant
Threespine Stickleback	*Gasterosteus aculeatus*	Transitional	Lake	Unclassified
Ninespine Stickleback	*Pungitius pungitius*	Coldwater	Lake	Unclassified
SCULPINS	COTTIDAE			
Mottled Sculpin	*Cottus bairdii*	Coldwater	Small	Intolerant
Slimy Sculpin	*Cottus cognatus*	Coldwater	Small	Intolerant
Spoonhead Sculpin	*Cottus ricei*	Coldwater	Lake	Intolerant
Deepwater Sculpin	*Myoxocephalus thompsonii*	Coldwater	Lake	Intolerant
TEMPERATE BASSES	MORONIDAE			
White Perch	*Morone americana*	Warmwater	Large	Intermediate
White Bass	*Morone chrysops*	Warmwater	Large	Intermediate
Yellow Bass	*Morone mississippiensis*	Warmwater	Large	Intermediate
SUNFISHES	CENTRARCHIDAE			
Rock Bass	*Ambloplites rupestris*	Warmwater	Large	Intolerant
Green Sunfish	*Lepomis cyanellus*	Warmwater	Small	Tolerant
Pumpkinseed	*Lepomis gibbosus*	Warmwater	Medium	Intermediate
Warmouth	*Lepomis gulosus*	Warmwater	Large	Intermediate
Orangespotted Sunfish	*Lepomis humilis*	Warmwater	Large	Intermediate
Bluegill	*Lepomis macrochirus*	Warmwater	Large	Intermediate
Longear Sunfish	*Lepomis megalotis*	Warmwater	Medium	Intolerant
Smallmouth Bass	*Micropterus dolomieu*	Warmwater	Large	Intolerant
Largemouth Bass	*Micropterus salmoides*	Warmwater	Large	Intermediate

White Crappie	*Pomoxis annularis*	Warmwater	Large	Intermediate
Black Crappie	*Pomoxis nigromaculatus*	Warmwater	Large	Intermediate
PERCHES	PERCIDAE			
Western Sand Darter	*Ammocrypta clara*	Warmwater	Large	Intolerant
Crystal Darter	*Crystallaria asprella*	Warmwater	Large	Intolerant
Mud Darter	*Etheostoma asprigene*	Warmwater	Large	Intermediate
Rainbow Darter	*Etheostoma caeruleum*	Warmwater	Medium	Intolerant
Bluntnose Darter	*Etheostoma chlorosoma*	Warmwater	Large	Intolerant
Iowa Darter	*Etheostoma exile*	Warmwater	Small	Intolerant
Fantail Darter	*Etheostoma flabellare*	Warmwater	Small	Intermediate
Least Darter	*Etheostoma microperca*	Warmwater	Medium	Intolerant
Johnny Darter	*Etheostoma nigrum*	Transitional	Medium	Intermediate
Banded Darter	*Etheostoma zonale*	Warmwater	Large	Intolerant
Ruffe	*Gymnocephalus cernuus*	Transitional	Medium	Intermediate
Yellow Perch	*Perca flavescens*	Transitional	Large	Intermediate
Logperch	*Percina caprodes*	Warmwater	Large	Intermediate
Gilt Darter	*Percina evides*	Warmwater	Large	Intolerant
Blackside Darter	*Percina maculata*	Warmwater	Large	Intermediate
Slenderhead Darter	*Percina phoxocephala*	Warmwater	Large	Intolerant
River Darter	*Percina shumardi*	Warmwater	Large	Intermediate
Sauger	*Sander canadensis*	Warmwater	Large	Intermediate
Walleye	*Sander vitreus*	Transitional	Large	Intermediate
DRUMS	SCIAENIDAE			
Freshwater Drum	*Aplodinotus grunniens*	Warmwater	Large	Intermediate
GOBIES	GOBIIDAE			
Round Goby	*Neogobius melanostomus*	Warmwater	Large	Intermediate
Tubenose Goby	*Proterorhinus marmoratus*	Warmwater	Lake	Intermediate

Appendix: Worksheet to Document Natural Community Verification Process

Stream Name: ____

WBIC: ________________ *County:* __________________ *Sample Date:* __________

Sample Location: ____

____

SWIMS Station ID: __________________ *SWIMS Sample ID:* ___________________

Predicted Natural Community (NC): ____

FINAL NATURAL COMMUNITY: ____

Question 1: Do observed and expected percentages for fish thermal and stream-size guilds agree?

<u>Thermal Guild Percentages</u>:

Expected: Coldwater: ________ Transitional: ________ Warmwater: ________

Observed: Coldwater: ________ Transitional: ________ Warmwater: ________

If Observed Percentages all within Expected Ranges, <u>retain Predicted Thermal NC as Final Thermal NC</u>.

If Observed Percentage NOT all within Expected Ranges, <u>go to *Question 2*</u>.

<u>Stream-Size Guild Percentages</u>:

Expected: Small: ________ Medium: ________ Large: ________

Observed: Small: ________ Medium: ________ Large: ________

If Observed Percentages all within Expected Ranges, <u>retain Predicted Stream-Size NC as Final Stream-Size NC</u>.

If Observed Percentage NOT all within Expected Ranges, <u>go to *Question 2*</u>.
Question 2: Is Segment degraded?

Tolerance Guild Percentages:

Expected: Intolerant: ___> 0%__ Tolerant: ________

Observed: Intolerant: ________ Tolerant: ________

If EITHER of the Observed Percentages is within Expected Ranges, segment is unlikely to be degraded. Go to *Question 3*.

If BOTH of the Observed Percentages are NOT within Expected Ranges, segment is likely to be degraded. Retain Predicted NC as Final NC.

Question 3: Could weather extremes have affected fish guild percentages?

Nearest Weather Station (ID Number): ____

Month Before Fish Sample: _______ 12 Months Before Fish Sample: _____________

Mean Monthly Air Temperature:

Start Year: ________ End Year: ________ Years of Data: _______

Minimum Monthly Mean: _________ Maximum Monthly Mean: _________

Mean for Month before Sample: _______ Rank: _____ Warmest _____ Coldest

10th Percentile Monthly Mean: _______ 90th Percentile Monthly Mean: _______

If Mean Air Temperature for the Month before is in top or bottom 10% of Long-Term Monthly Mean Air Temperature, and the temperature extreme prior to sampling is consistent with the direction of the difference between observed and expected fish thermal guilds, then EXTREME WEATHER may confound the Natural Community Verification. Collect a new fish sample when extreme weather is not a factor and redo the analysis beginning with *Question 1*.

If Air Temperature was NOT EXTREME before sampling or if the extreme was NOT CONSISTENT with the fish community differences, go to analysis of whether Total Annual Precipitation before sampling was extreme.

Total Annual (12months before sample) Precipitation**:**

Start Year: _______ End Year: _______ Years of Data: _____

Minimum 12-Month Total: _________ Maximum 12-Month Total: _________

Total for Year before Sample: _______ Rank: _____ Wettest _____ Driest

10th Percentile 12-Month Total: _______ 90th Percentile 12-Month Total: _______

If Total Precipitation for the year before the sample is in top or bottom 10% of Long-Term Total Annual Precipitation, and the precipitation extreme prior to sampling is consistent with the direction of the difference between observed and expected fish stream-size guilds, then EXTREME WEATHER may confound the Natural Community verification. <u>Collect a new fish sample when extreme weather is not a factor and redo the analysis beginning with *Question 1*</u>.

If Precipitation was NOT EXTREME before sampling, or if the extreme was NOT CONSISTENT with fish community differences, <u>go to *Question 4*</u>.

Question 4: Based on Best Professional Judgment, can other factors account for the differences between observed and expected fish thermal and stream-size guild percentages?

Do other factors support either retaining the Predicted Natural Community or collecting new fish data and repeating the analysis? Yes: ____ No: ____

If "Yes", describe why: ____

____

____

____

If "Yes", <u>retain Predicted NC as the Final NC or collect a new fish sample and repeat analysis beginning with *Question 1*</u>, as appropriate.

If "No", <u>designate a new Final NC based on observed percentages of fish thermal and stream-size guilds</u>.

APPENDIX E. Consensus-Based Sediment Quality Guidelines Recommendations for Use & Application